VOL. XII. Part 3.—pp. 205-362.

NOVEMBER, 1921.

BULLETIN OF ENTOMOLOGICAL RESEARCH

LONDON.

THE IMPERIAL BUREAU OF ENTOMOLOGY,

41, QUEEN'S GATE, S.W. 7.

Price 5s. net.

All Rights Reserved.

IMPERIAL BUREAU OF ENTOMOLOGY.

HONORARY COMMITTEE OF MANAGEMENT.

THE VISCOUNT HARCOURT, Chairman.
LIEUT.-COLONEL A. ALCOCK, C.I.E., F.R.S.
MAJOR E. E. AUSTEN, D.S.O.
DR. A. G. BAGSHAWE, C.M.G.
MAJOR-GENERAL SIR JOHN R. BRADFORD, K.C.M.G., F.R.S.
MAJOR-GENERAL SIR DAVID BRUCE, K.C.B., F.R.S.
MR. J. C. F. FRYER.
SIR S. F. HARMER, K.B.E., F.R.S.
PROF. H. MAXWELL LEFROY.
THE HON. SIR E. LUCAS.
DR. R. STEWART MACDOUGALL.
SIR JOHN McFADYEAN.
SIR PATRICK MANSON, G.C.M.G., F.R.S.
SIR DANIEL MORRIS, K.C.M.G.
PROF. R. NEWSTEAD, F.R.S.
PROF. G. H. F. NUTTALL, F.R.S.
PROF. E. B. POULTON, F.R.S.
LIEUT.-COLONEL SIR DAVID PRAIN, C.M.G., C.I.E., F.R.S.
SIR H. J. READ, K.C.M.G., C.B.
THE HON. N. C. ROTHSCHILD.
DR. HUGH SCOTT.
SIR A. E. SHIPLEY, G.B.E., F.R.S.
MR. R. A. C. SPERLING, C.M.G.
SIR STEWART STOCKMAN.
MR. F. V. THEOBALD.
MR. C. WARBURTON.

Director.
Dr. GUY A. K. MARSHALL, C.M.G.

Assistant Director.
Dr. S. A. NEAVE.

Secretary.
Mr. A. C. C. PARKINSON.

THE INFLUENCE OF DROUGHT UPON MOSQUITO LIFE IN SURREY.

By MALCOLM E. MACGREGOR,

Wellcome Bureau of Scientific Research
(Wellcome Field Laboratory, Wisley, Surrey).

The unusual and prolonged drought that we have experienced this year has had a marked effect upon the mosquitos. So much so, that while last year I found no difficulty in obtaining any of the eleven species which so far have been found to exist in this locality, yet for many weeks now it has been impossible to obtain any but a few *Anopheles maculipennis* (adults), *Anopheles bifurcatus* (larvae), *Culicella morsitans* (larvae, pupae, and adults), and *Culex pipiens* (larvae, pupae and adults).

As I have been anxious to get specimens of the other species, which were common around here last year, in order to continue certain observations, I have made prolonged searches for them in the usual breeding-places, only to find that with most of the water collections dried up none of the species required was obtainable.

Anopheles bifurcatus.

Normal conditions.—As larvae and pupae ; plentiful in slowly moving streams throughout the year. As adults ; fairly numerous in pigsties from end of March to June, but unobtainable later.

Conditions during drought.—As larvae and pupae ; unobtainable, except in an abnormal breeding-place (well). As adults ; unobtainable since late in June.

Last year I found that large numbers of *Anopheles bifurcatus* larvae were to be found in a certain stream at Ockham throughout the summer and winter of 1920 and until the streams dried up in June of this year. The only permanent water in the vicinity was a small lake in which no Anopheline larvae were discovered last year.

I thought it probable that the *Anopheles bifurcatus* females after the stream had dried up would be forced to oviposit on the water of this lake, but repeated search has failed to discover larvae in the lake even under the present conditions of water shortage.

Soon after, having made an extensive search for Anopheline larvae along the banks on all sides of the lake, I came across a disused well in an open field near-by. Its top was covered by a loosely fitting lid, and the water in the well was about five feet deep, standing at about ten feet below the well-mouth. When examined, the water was found to be crowded with the larvae of *Culicella morsitans*, associated with which were numerous larvae of *Anopheles bifurcatus* in all stages of growth. Such an unusual situation for *Anopheles bifurcatus* larvae, moreover in water that was turbid and foul, is surely an outcome of the scarcity of water and the loss of normal breeding-places. It is nevertheless difficult to account for the females' choice of this situation instead of the water of the lake, around whose weed-protected bays the eggs might be laid in security against attack by fish. Under normal conditions, *Anopheles bifurcatus* chooses water that is clear and cool on which to lay her eggs.

The well, however, is the only situation where *Anopheles bifurcatus* larvae have been found, and the proportion of adults of this species which can be emerging at present must be infinitesimal compared with the normal.

(4183) P8/170 1000 9/21 Harrow G 75

Anopheles maculipennis.

Normal conditions.—As larvae and pupae; plentiful in farm ponds and small lakes from end of March until October. As adults; very numerous in pigsties throughout the spring and summer months. Hibernating females common during the winter months.

Conditions during drought.—As larvae and pupae; numbers relatively reduced owing to drying up of many normal breeding-places; but in certain permanent small lakes, actual numbers of larvae and pupae increased, probably on account of the scarcity of available breeding-places. As adults; plentiful but not actually numerous in pigsties.

It appears from my observations locally that *Anopheles maculipennis* is the species least affected by the drought. It chooses as a favourite breeding-place the shores of large and small natural ponds and lakes which are, of course, the last waters to dry up in conditions of drought; and this species is consequently one of the last to experience difficulty in obtaining breeding-places.

I should mention that pigsties in this locality have been found to be the favourite haunts of adult *Anopheles maculipennis* and *Anopheles bifurcatus*, and that these mosquitos are rarely found in stables. This state of affairs, which is so very different from that in other parts of the country, is, I think, due entirely to the fact that all the stables which I have visited in this county are ventilated at the junction of the wall and roof. This method ensures a very thorough ventilation, and the average temperature in the stables is much lower than the average temperature in stables where ventilation is afforded by a few windows. Furthermore, because of the architecture, the amount of light in the average stable in Surrey is much greater than that found in the average stable in Kent for instance, where Anophelines frequent the stables in large numbers. This is a matter of such significance that attention should be drawn to the value of the design in providing an " all-the-way-round " ventilation between the walls and roof, as preventing the accumulation of mosquitos in stables.

The local pigsties, on the other hand, are low-built and the contained atmosphere is close and warm at all times of the year, so that very favourable conditions are maintained for the accumulation of mosquitos when they seek a blood meal, and also conditions favourable to the hibernating females during the winter.

Anopheles plumbeus.

Normal conditions.—As larvae and pupae; found in almost every water-containing tree-hole in a variety of different kinds of trees throughout the summer and winter months. As adults; seldom observed, but occasionally in association with *Ochlerotatus* spp. they have shyly attacked me while I have remained quietly seated in the woods.

Conditions during drought.—As larvae and pupae; unobtainable now for many weeks (last captured about middle of May), as all water in tree-holes has completely evaporated. As adults; none observed since middle of May.

Anopheles plumbeus in this locality is quite common as larvae in water-containing tree-holes and, as usual, is often associated with the larvae of *Finlaya geniculata.*

Very few adults have been observed, and the one or two that I have caught sight of have eluded capture. I have been anxious to obtain adult females for some time, so as to get ova for the completion of certain observations. It occurred to me that possibly another way of obtaining ova would be carefully to clear of detritus one of the tree-holes in which *Anopheles plumbeus* had been breeding, and to keep it filled with water artifically. Unfortunately this plan did not succeed, as such hosts of insects regarded it as a providential water-supply when water was difficult to obtain that the entrance to the hole was constantly choked with a seething mass of thirsty insects.

Culex pipiens.

Normal conditions.—As larvae and pupae; abundant principally in water-troughs, rain-water barrels and other artificial water collections. As adults; abundant in houses, cellars, stables, etc.

Conditions during drought.—As larvae and pupae; relative numbers reduced, but actual numbers in available breeding-places often increased. As adults; easily found in considerable numbers, but not so numerous as in normal years.

Culex pipiens being a species that largely makes use of artificial water collections used by man, it follows that often these collections are maintained by him in spite of dry weather, and thus *Culex pipiens* is not at so great a loss to find breeding-grounds as are the less domestic mosquitos.

Culicella morsitans.

Natural conditions.—As larvae and pupae; commonly found in certain wayside ditches and in rain-water barrels. As adults; quite common in out-houses, stables, cellars and outside latrines, but never found in large numbers at a time.

Conditions during drought.—As larvae and pupae; scarce and now only found in one rain barrel kept supplied with water artificially, and in one instance found in a shallow well ten feet below ground. As adults; none observed for many weeks.

Culicella fumipennis.

Normal conditions.—As larvae and pupae; common in certain wayside ditches. As adults; frequently found on the walls in out-houses and stables.

Conditions during drought.—As larvae and pupae; unobtainable. As adults; unobtainable.

Finlaya geniculata.

Normal conditions.—As larvae and pupae; abundant in the water-containing holes in a variety of trees. Often associated with the larvae and pupae of *Anopheles plumbeus*. As adults; sometimes observed to attack human beings while they are in the woods, though not very often seen.

Conditions during drought.—As larvae and pupae; unobtainable since middle of June. As adults; unobtainable, and not observed in the woods since beginning of June.

Soon after the tree-holes had begun to dry up generally, numerous larvae and pupae of *Finlaya geniculata* were collected from several holes that still contained water, and these were brought to the laboratory for experiments on their development in waters giving different reactions. Many were placed under conditions that highly favoured development and emerged as large and active mosquitos. They were at first kept in a cage in the laboratory and fed upon dates and human blood in an attempt to obtain ova from them, but while all the females partook of an ample diet, fertilisation apparently would not take place under caged conditions, even when there were about an equal number of active and healthy males in association. In the hope of getting ova from them under natural conditions, the whole batch of mosquitos was carefully captured in tubes and taken to the vicinity of a beech-tree in which the tree-holes were kept full of water, and there released. Possibly on account of the fact that the water in the holes was besieged by insects of all kinds (see under *Anopheles plumbeus*), no eggs were laid, nor were any of the released mosquitos seen again.

It was observed in the laboratory that the "bite" of *Finlaya geniculata* is distinctly painful. The proboscis is large and the initial prick of the "bite" is sharp, but unlike the usual conditions when other mosquitos bite (a painless period following the initial prick when once the insect has got the proboscis well embedded in the tissues and has begun to feed), the initial prick from *Finlaya geniculata* is followed by a burning sensation, which continues and increases while the insect feeds; so much so that a good deal of will-power has to be exercised against the impulse to jerk the mosquito off. The subsequent effects of the "bite" are not, however, more serious than the usual effects of a mosquito bite.

Ochlerotatus caspius.

Normal conditions.—As larvae and pupae; found in numbers in a woodland pool near Ockham. As adults; not observed under natural conditions, but several bred out from larvae in the laboratory.

Conditions during drought.—As larvae and pupae; unobtainable; pool completely dried up since last May. As adults; unobtainable.

Ochlerotatus nemorosus.

Normal conditions.—As larvae and pupae; abundant in woodland pools and streams. As adults; very large numbers obtainable in the woods, where, particularly in the afternoons, they attack so persistently that there is no peace to be had.

Conditions during drought.—As larvae and pupae; unobtainable since the woodland pools dried up in May. As adults; unobtainable since about the middle of June, when it was found that even in the afternoons one might frequent the woods in peace, unmolested by a single mosquito—a state of affairs very different from what obtained during the whole of the summer months last year.

Ochlerotatus waterhousei.

Normal conditions.—As larvae and pupae; numerous in certain woodland pools. As adults; numerous in the woods where, associated with *Ochlerotatus nemorosus*, they persistently attack human beings, particularly in the afternoons.

Conditions during drought.—As larvae and pupae; unobtainable since end of May. As adults; unobtainable since May.

Theobaldia annulata.

Normal conditions.—As larvae and pupae; numerous in certain wayside ditches and in rain-water barrels. As adults; common in stables and outhouses, though never numerous.

Conditions during drought.—As larvae and pupae; unobtainable. As adults; a few still obtainable in pigsties in association with *Anopheles maculipennis*.

* * * * * * *

From the foregoing records it will be seen that drought tends to affect the mosquito population of an area adversely, decreasing the normal breeding-places, and in some instances, in the case of particular species, causing the normal breeding-places to disappear entirely. This is true for such species as *Anopheles plumbeus*, *Finlaya geniculata*, *Ochlerotatus caspius*, *Ochlerotatus nemorosus* and *Ochlerotatus waterhousei*. It will be interesting, therefore, to see whether these species will be

rare in this locality during future years. Predictions were made by several people at the beginning of the hot weather that there would probably be an enormous increase in the number of mosquitos all over the country, and that in consequence, with the large numbers of ex-soldiers in our midst who had suffered from malaria, we should probably see many new cases of indigenous malaria. The reverse has been true. I learn from the Ministry of Health that the number of cases of indigenous malaria contracted in England in 1920 was 36; whereas in 1921, up to the 29th August, only four cases had been recorded. Hot weather is obviously only one of the many factors in the malaria equation. Even in England, where it had been maintained that the historical epidemics of malaria have been occasioned by a hot summer following the return of malaria-infected troops from abroad, it will be clear that this combination is not all that is necessary to produce even a mild epidemic of indigenous malaria.

SOME COCCIDAE FROM EASTERN ASIA.

By G. F. Ferris,

Stanford University, California.

Through the kindness of Professor E. O. Essig, of the University of California, I have been enabled to examine a collection of Coccidae from Formosa, made by M. Maki and S. Inamura, and also a small amount of material from Foochow, China, collected by Mr. C. R. Kellogg. It is upon this material that the present paper is for the most part based. In addition to this, I am taking advantage of the opportunity to rectify certain errors that have been made in the identification of a few species from Japan.

The material from Formosa is especially interesting, as nothing appears to have been published concerning the Coccid fauna of that island. The majority of the species here recorded are widely-distributed forms ; a few are known from Japan ; and several are species that have heretofore been recorded only from India, Ceylon and Java. While the number of species dealt with is not sufficiently large to permit of any generalisation, there is at least a suggestion that the Coccid fauna of Formosa is more closely related to that of southern Asia than to that of Japan.

The types of the new species here described are in the Stanford University Collection.

Icerya seychellarum (Westw.).

On *Morus alba* and *Citrus* sp., Taihoku, Formosa.

Icerya purchasi (Maskell).

On *Citrus* sp., Taihoku, Formosa.

Pseudococcus filamentosus (Ckll.).

On *Citrus* sp., Taihoku, Formosa.

Pseudococcus comstocki (Kuwana).

On *Citrus* sp., Taihoku, Formosa. Previously recorded from Japan and the United States.

Pseudococcus virgatus (Ckll.).

On *Baphinia* sp., Ako, Formosa.

Pseudococcus citri (Risso).

On *Morus alba*, Ako, Formosa.

Antonina bambusae (Maskell).

On *Bambusa stenostachya*, Taihoku, Formosa. This is the species that has ordinarily passed under the name of *Chaetococcus bambusae*. I am entirely in accord with Green in the opinion that *Chaetococcus* cannot be maintained as distinct from *Antonina*.

Antonina crawii (Ckll.).

1902. *Eriococcus graminis* (?) Maskell ; Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 50.

On bamboo, Taihoku, Formosa. Kuwana (ref. cited) has recorded *Eriococcus graminis*, Maskell, from Japan. I have at hand the specimens upon which the record was based and they prove to be nothing more than immature stages of an *Antonina*, without much doubt *A. crawii*.

Cerococcus ficoides (Green).

On *Mallotus japonica*, Taihoku, Formosa. Previously known only from the original record, on tea from Bengal. The excellent description and figures given by Green render the identification practically certain.

Tachardia decorella (Maskell).

On *Ficus retusa* and undetermined host, Taihoku, Formosa.

Mallococcus sinensis (Maskell).

On undetermined host, Foochow, China. I have at hand part of the type material of this species and would redescribe it here (it is hardly or not at all recognisable from the original description) were it not that another author has a redescription now in press.

Ceroplastes rubens (Sign.).

On *Citrus*, Ako, Formosa.

Coccus bicruciatus (Green).

On *Murraya exotica*, Taihoku, Formosa. Previously recorded only from Ceylon.

Coccus elongatus (Sign.).

On *Acacia confusa, Codiaeum variegatum, Gossypium herbaceum, Hibiscus rosa-sinensis* and *Myrica rubra*, at Taihoku, and on *Morus alba* at Ako, Formosa.

Saissetia hemisphaerica (Targ.).

On *Gardenia florida*, Taihoku, Formosa.

Fig. 1. *Aulacaspis cinnamomi* (Newstead) : A, adult female ; B, portion of pygidial margin ; C, pygidium.

Aulacaspis cinnamomi (Newstead) (fig. 1).

On *Cinnamomum camphora*, Taihoku, Formosa. Previously recorded only from *Cinnamomum ceylanicum* in Java.

The specimens at hand differ somewhat from the figures given by Newstead, but these figures are not entirely clear, and in view of the close similarity in general appearance and in hosts I am inclined to assume that the figures are in error. I am presenting new figures. The species is certainly an *Aulacaspis*.

Aulacaspis rosae (Bouché).

On cultivated rose, Taihoku, Formosa.

Aulacaspis pentagona (Targ.).

On *Morus alba*, Taihoku, Formosa.

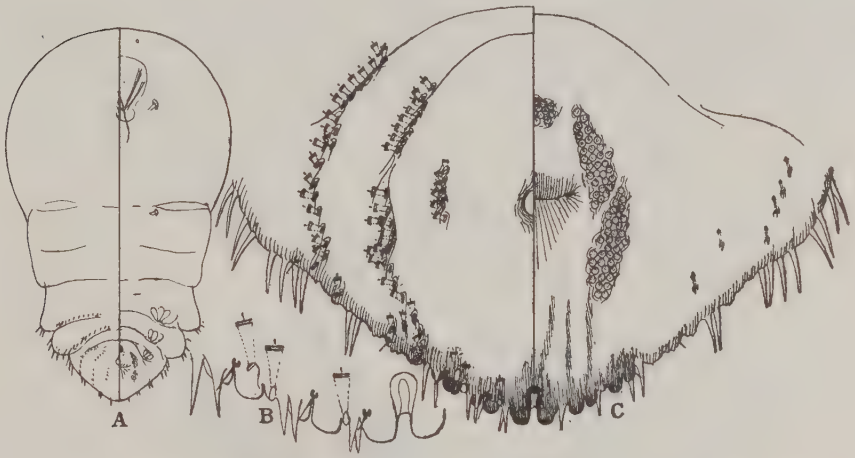

Fig. 2. *Aulacaspis tegalensis* (Zehntner): A, adult female; B, portion of pygidial margin; C, pygidium.

Aulacaspis tegalensis (Zehntner) (fig. 2).

On sugar-cane, Taihoku, Formosa. Previously recorded from Java and Mauritius. My determination is on the basis of specimens from Java.

I know of no figures of this species other than those given by Zehntner, which are in out-of-the-way publications and are in addition not especially satisfactory, and as the species is likely to be of some economic importance I am presenting new figures. I regard it as an *Aulacaspis* rather than a *Chionaspis*.

Phenacaspis eugeniae (Maskell).

On *Michelia fuscata*, Taihoku, Formosa.

The exact identity of Maskell's *Chionaspis eugeniae* appears to be in doubt, for there occurs in the Pacific region a series of forms which are very closely related. The Formosa specimens agree closely with examples from Hawaii which have been determined as *eugeniae*.

Chionaspis annandalei (Green).

On *Bambusa stenostachya*, Taihoku, Formosa. Previously known only from India.

Pinnaspis simplex, sp. n. (fig. 3).

From undetermined host, Foochow, China.

Scale of the female 1·5 mm. long, elongate, narrow, dark brown. Scale of the male not observed.

Female 0·9 mm. long, of the usual elongate form, the derm membranous throughout except for the pygidium. Margins of the abdominal segments projecting but little, without gland spines or at the most with a single gland spine on the last segment anterior to the pygidium, with numerous marginal ducts. Dorsum without ducts. Anterior spiracles with a small group of pores. Pygidium (fig. 3) acutely pointed, the median lobes alone developed, apparently fused, their outer edges crenulate. Extending into the pygidium from the median lobes is a slender, elongate median thickening. Beyond the median lobes there is first a small prominence followed by two setae, one of which has a conspicuously chitinised socket, a gland spine, two submarginal pores, a seta, a submarginal pore, two gland spines and a submarginal pore. Dorsum of the pygidium without pores except for the marginal series and a single pore representing the front row. Anal opening close to the anterior margin of the pygidium. Circumgenital pores in five groups.

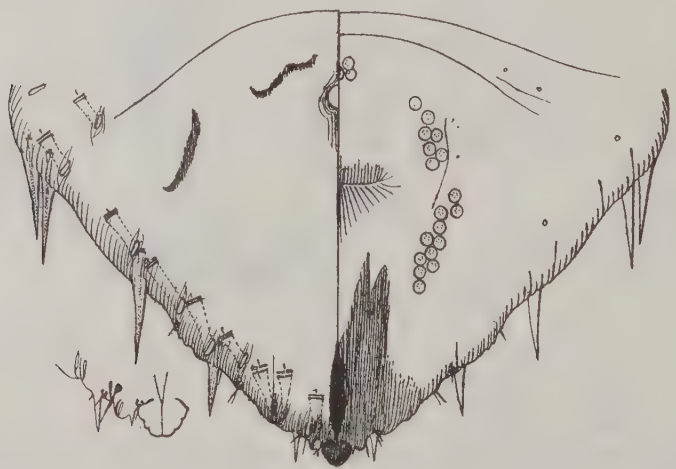

Fig. 3. *Pinnaspis simplex*, sp. n. : pygidium and portion of pygidial margin.

Notes.—Specimens of this species have been examined by Mr. E. E. Green, who agrees with me that it is undescribed. It is characterised by the single pair of lobes and is quite distinct from any other species known to me. I may note that I am considering the genera *Pinnaspis* and *Hemichionaspis* as synonymous.

Pinnaspis minor (Maskell).

On undetermined host, Taihoku, Formosa.

Parlatoria pergandei (Ckll.).

On palm (?), Foochow, China, and on *Thea sinensis* and undetermined host at Taihoku, Formosa.

Parlatoria zizyphi (Lucas).

On *Citrus* sp., Taihoku, Formosa.

Fiorinia japonica (Kuwana) (fig. 4, C).

1902. *Fiorinia fioriniae* var. *japonica,* Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 79 (part).

From *Pinus thunbergii,* Taihoku, Formosa. Originally recorded from *Pinus* sp. and *Podocarpus chinensis* in Japan, the latter record in error.

In the original description of this species as a variety of *F. fioriniae* the type host was not designated. I find the material recorded by Kuwana to include two species and designate as a lectotype a specimen from *Pinus.* The specimens from *Podocarpus* I consider to belong to *F. juniperi,* Leonardi.

Fig. 4. Pygidial margins of : A, *Fiorinia fioriniae* (Targ.), from palm in the United States ; B, *F. juniperi,* Leonardi, from *Podocarpus chinensis* in Japan ; C, *F. japonica,* Kuwana, from *Pinus* in Japan ; E, *F. chinensis,* sp. n. ; F, *F. chinensis,* sp. n., second stage. D, pygidium of *F. chinensis,* sp. n.

Kuwana separated this form from *F. fioriniae* on the grounds of the larger number of circumgenital pores, but there appear to be more satisfactory characters in the number and arrangement of the marginal tubular ducts of the pygidium. In *F. fioriniae* (fig. 4, A) there are not more than four large ducts followed by as many small ducts. Otherwise the two species are very similar.

Fiorinia juniperi (Leonardi) (fig. 4, B).

1902. *Fiorinia fioriniae* var. *japonica,* Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 79 (part).

Specimens from *Podocarpus chinensis* in Japan were included by Kuwana under *F. fioriniae* var. *japonica,* but I consider them to belong rather to *F. juniperi.* They agree very closely with specimens of *juniperi* (det. Green) from Ceylon. The species, like *japonica,* is very similar to *fioriniae,* but differs in having as many as eight large marginal ducts instead of four on the pygidium (fig. 4, B).

Fiorinia chinensis, sp. n. (fig. 4, D, E, F).

From undetermined host from China, taken in quarantine at San Francisco.

Scale not available for description.

Female 0·75 mm. long. Without a process between the bases of the antennae, with no pores about the spiracles and with at the most a very few small gland spines on the margins of the abdominal segments. Pygidium (fig. 4, D), with the median lobes quite large, rounded, minutely serrate, connected at the base and bounding a median notch in which are a pair of small gland spines. Second pair of lobes (fig. 4, E) represented merely by a pair of small tooth-like projections. Between the first and second lobes is the opening of a duct and beyond the second lobe are two more submarginal ducts, all quite small. Circumgenital pores present, forming an almost continuous arch.

Second stage without marginal projections on the abdomen, the pygidium (fig. 4, F) with a deep median notch, the median lobes narrower than in the adult, the second pair represented by a single undivided lobe. Lateral margins of the pygidium with several small gland spines and with five submarginal ducts.

Notes.—This species would appear to belong to Leonardi's genus *Trullifiorinia*, but I am not at present inclined to accept his groups. It somewhat resembles *F. rubrolineata*, Leon., but differs in the larger lobes and submarginal ducts.

Lepidosaphes beckii (Newman).

On *Murraya exotica*, Taihoku, Formosa.

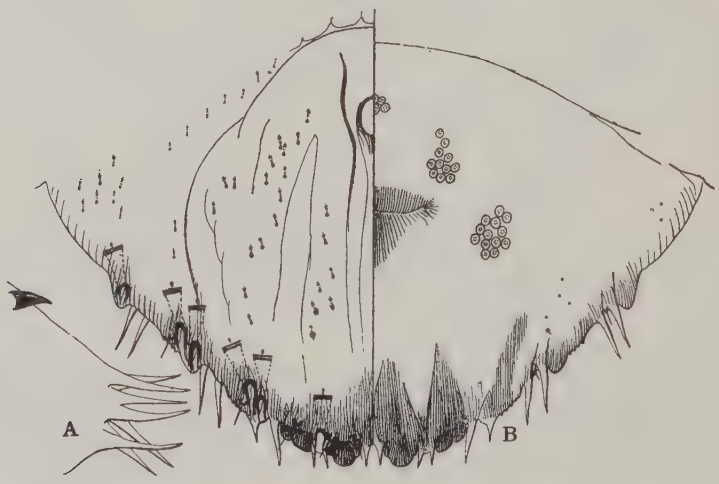

Fig. 5. *Lepidosaphes tubulorum*, sp. n.: A, lateral margin of abdominal segment; B, pygidium.

Lepidosaphes tubulorum, sp. n. (fig. 5).

1902. *Mytilaspis pomorum* (L.); Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 80 (part).

Type from *Sapium sebiferum*, Taihoku, Formosa. Also from *Salix warburgi* at the same place, and from *Ilex crenata*, willow and currant in Japan.

Scales of male and female of the type common to the genus, dark brown, the former moderately broad, length 2·75–3 mm.

Female 1·1 mm. long, elongate, rather broad ; the derm membranous except for the pygidium ; the margins of the last three abdominal segments projecting and bearing numerous gland spines and likewise bearing a small spur-like, chitinised process (fig. 5, A). In some specimens this process may be developed on but part of the segments. Dorsum of the abdomen with large numbers of extremely small ducts.

Pygidium (fig. 5, B) with two pairs of lobes ; the median pair widely separated, broad and with a deep subapical notch on each side, the second pair bilobed. Between the median lobes is a pair of small gland spines ; between the median and second lobes a pore prominence with two small projections ; beyond the second lobes a gland spine, a pore prominence with two large pores, two gland spines, two large marginal pores, two gland spines and two pores. Margins of the marginal pores heavily chitinised. Dorsal ducts extremely minute, arranged in three irregular areas somewhat variable in number. Circumgenital pores in five groups of 6–13 pores.

Notes.—The specimens recorded from Japan were included by Kuwana in *Lepidosaphes ulmi* (=*Mytilaspis pomorum*) along with specimens really referable to that species and others (from orchid) belonging to a species that I shall not here consider because of the scantiness of the material. While *L. tubulorum* is indeed quite similar to *L. ulmi*, it is readily separable by the small size and the arrangement of the dorsal ducts.

Fig. 6. *Lepidosaphes japonica*, Kuwana : pygidium.

Lepidosaphes japonica (Kuwana) (fig. 6).

1902. *Mytilaspis pomorum* var. *japonica*, Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 80.

From *Abies firma*, Japan.

I have at hand the types and type material of this species. It cannot be regarded as having any connection with *L. ulmi*, being in fact a very distinct species. I present the following notes.

Female with the derm unchitinised except for the pygidium. Margins of the abdominal segments projecting, the last three with three or more gland spines, the margins of both thorax and abdomen and the dorsum of the abdomen with numerous moderately large ducts. Pygidium (fig. 6) with two pairs of lobes, the median pair rounded, the second pair bilobed. Between the median lobes are two small gland spines ; between the median and second lobes a pore prominence with two projecting points ; beyond the second lobes two small gland spines, two large submarginal pores, two gland spines, two pores, three gland spines and a pore. Margins of the marginal pores heavily chitinised. Dorsal ducts only slightly smaller than the marginal ducts, arranged in three rows as indicated in the figure.

Genus **Pygalataspis,** nov.

Diaspidine COCCIDAE referable by the character of the ducts to the *Diaspis* series, that is with the ducts short, relatively broad and with a pair of transverse bars across the inner extremity. Ducts abundant on the pygidium, both dorsally and ventrally, not arranged in rows. Gland spines of the ordinary simple type lacking, being replaced by a series of short, broad, variously toothed plates along the margin of the pygidium, these plates apparently arising in part from the margins of the lobes. Two pairs of lobes or lobe-like processes present, the outer pair not bilobed. Circumgenital pores present in five groups. Scale of both sexes elongate, with the exuviae at one end, that of the female with the dorsal and ventral portions continuous, the ventral scale composed in part of the ventral portion of the second exuviae.

Type of the genus, *Pygalataspis miscanthi,* sp. n.

Notes.—In the abundance and distribution of the ducts and the correlated characters of the scale this genus most closely resembles *Odonaspis,* but the peculiarly shaped plates and the extraordinarily large lobes are quite unlike anything else with which I am familiar. The genus *Odonaspis* is usually attached to the *Aspidiotus* series of the DIASPIDINAE, but I am inclined to doubt the correctness of this placing, regarding it rather as belonging to the *Diaspis* series.

Pygalataspis miscanthi, sp. n. (fig. 7).

From *Miscanthus sinensis* (a grass), Taihoku, Formosa.

Scale of the female about 2·5 mm. long, elongate, white or brownish ; scale of the male similar in form and colour to that of the female, about 1 mm. long.

Female (fig. 7, B) elongate, with nearly parallel sides, the margins of the abdominal segments projecting but little or not at all, the derm membranous except for the pygidium and the lateral margins of the last two or three abdominal segments which are heavily chitinised. Lateral margins of the metathorax, and of all the abdominal segments and the dorsum of the last two segments with numerous ducts of the type shown in fig. 7, D.

Pygidium (fig. 7, A) with the marginal area heavily chitinised and more or less folded. Two pairs of large, rounded lobes or lobe-like processes present, each with a broad, flattened, irregularly toothed plate arising from the outer margin, the plates of the second pair larger than those of the median pair. Beyond the second is a cluster of two or three smaller plates. Setae at the bases of the lobes, both dorsally and ventrally, long and slender. Tubular ducts very abundant, all small, those of the venter confined to a broad marginal zone. Circumgenital pores in five groups of 15 or more pores.

Second stage with the pygidium (fig. 7, C) terminating in a pair of prominent, pointed processes, which bear small plates as in the adult, and with a few small plates

along the lateral margin beyond the lobes. Ducts few, relatively large, confined to a submarginal series. Second exuviation occurring by the splitting of the derm about the posterior lateral margin, the ventral portion becoming incorporated in the ventral scale.

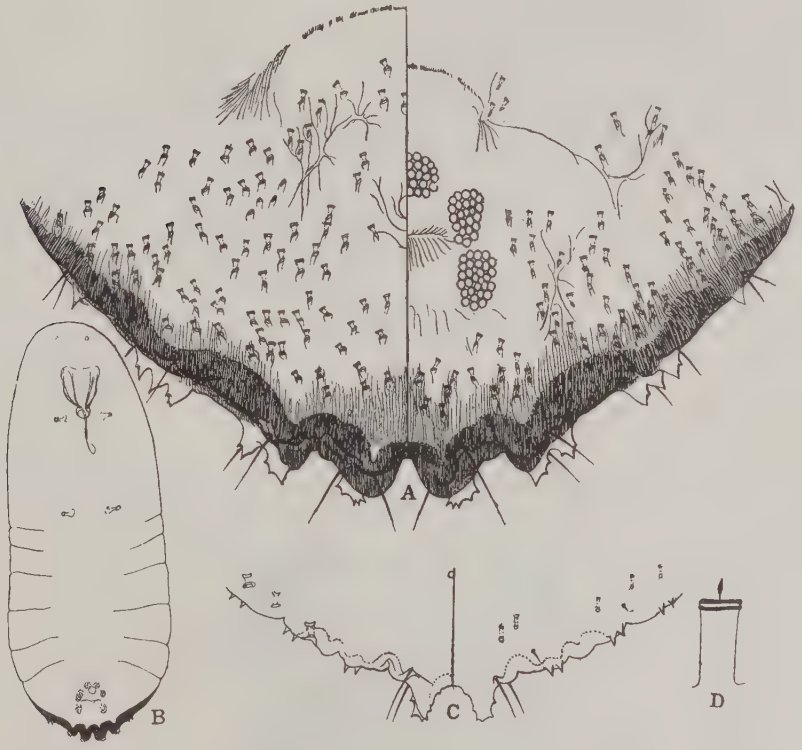

Fig. 7. *Pygalataspis miscanthi*, sp. n.: A, pygidium; B, adult female; C, pygidial margin of second stage; D, type of duct.

Odonaspis penicillata (Green).

1902. *Aspidiotus inusitatus*, Green; Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 65 (misidentification).

On *Bambusa stenostachya*, Taihoku, Formosa. Specimens recorded from Japan as *O. inusitata* by Kuwana (ref. cited) are this species instead.

Aspidiotus lataniae (Sign.).

On *Morus alba*, Ako, Formosa, and undetermined host from Formosa in quarantine at San Francisco.

Chrysomphalus aurantii (Maskell).

On *Citrus* sp., Taihoku, Formosa.

Chrysomphalus aonidum (L.).
On *Cycas revoluta,* Ako, Formosa.

Pseudaonidia duplex (Ckll.).
On *Michelia fuscata,* Taihoku, Formosa.

Pseudaonidia trilobitiformis (Green).
On *Citrus* sp., Taihoku, Formosa.

THE LARVAL AND PUPAL STAGES OF THE BIBIONIDAE.

By Hubert M. Morris, M.Sc., F.E.S.

Entomological Department, Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden.

Several species of Bibionidae are very common in the adult state during the spring and early summer in Britain, but their larvae seem to have been very little studied. The latter frequently occur in large numbers together, and are from time to time reported to have caused damage to various crops.

Probably the commonest species of *Bibio* are *B. marci* and *B. johannis*, but several others are also very frequently met with. The life-history of *Bibio johannis*, L., has been fully dealt with previously (6), and in the present paper it is proposed to give some account of the life-histories of *Bibio marci*, L., *B. lacteipennis*, Ztt., and *B. venosus*, Mg.

I am greatly indebted to Dr. A. D. Imms for suggestions and advice during the course of this work, and for the material of *Bibio venosus*, and to Mr. F. W. Edwards for identifying the adults which have been reared.

Bibio marci, L.

Oviposition.

In the early part of May 1920, a number of adults of *Bibio marci*, of both sexes, were captured and placed in a glass jar, the top of which was covered with gauze.

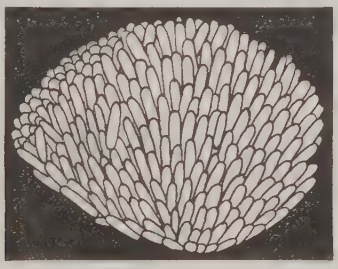

Fig. 1. Eggs of *Bibio marci*, × 6.

At the bottom of the jar a layer about 3 cm. in depth of fine damp soil was placed The flies were fed on sweetened water, and by this means it was found possible to induce the females to oviposit. After a day or two, the time probably varying with their age when captured, females were seen making their way into the soil. This is accomplished almost entirely by means of the fore legs, which are moved up and down in front of the head, with their tarsi bent back, the actual pressing back of the soil being done by the distal ends of the tibiae. In this manner a burrow just large enough to contain the fly is made, the insect turning over from time to time so that the soil is pressed aside in all directions. The burrows have a very irregular course, but the flies gradually make their way downwards into the soil.

At a little distance below the surface, the depth varying in different cases, a small cell is constructed which is of greater diameter than the burrow, and in this cell a mass of eggs is deposited, the eggs being arranged in an orderly manner (fig. 1).

The depth of soil in the jar was not sufficient to show the maximum depth to which the flies would penetrate for the purpose of oviposition, as some of the egg-masses were in contact with the bottom of the jar, 3·5 cm. below the surface.

After oviposition the flies soon died, usually just outside the cell containing the eggs.

Eggs.

The jar containing the soil in which the eggs had been laid was placed in the laboratory, the soil being kept damp. The eggs were observed to hatch in from 33 to 35 days after being laid, all those in a mass hatching more or less at the same time.

The eggs are white when first laid, but soon afterwards darken at both ends. They are almost cylindrical, with rounded extremities, the diameter of one end being slightly greater than that of the other, and they are slightly curved. Their length is from 0·73 mm. to 0·76 mm.; their diameter at the larger end 0·18 mm., and at the narrower end 0·15 mm.

The eggs appear rather opalescent owing to their being covered with small projections on the chorion.

Fig. 2. Newly hatched larva of *Bibio marci*, lateral view; setae of right side omitted; × 65.

Newly hatched Larva.

The newly hatched larva (fig. 2) is about 1·6 mm. in total length, the length of the head being about 0·25 mm. The head is relatively large, of a pale yellowish-brown colour, and bears a number of relatively long setae.

The body is colourless and transparent, the contents of the alimentary canal showing through as a dark line. The body is divided into twelve segments, each bearing a number of long, slender setae. There is, in addition, a much greater number of shorter setae, all the setae arising from enlarged conical bases.

At this stage the larva bears a single pair of spiracles, which are situated on the twelfth segment, in a corresponding position to that occupied by the spiracles of that segment in the full-grown larva.

The head and mouth-parts are very similar to those of the full-grown larva. The mandibles are shorter, with relatively longer teeth; the maxillae are similar to those of the older larva; the projections at the anterior end of the submentum of the labium are sharper and relatively longer, and there is a median projection between them, which is not present in that of the full-grown larva.

Fully grown Larva.

Well grown larvae of *Bibio marci* were found in considerable numbers during the winter amongst the decaying remains of grass which had been cut the year before, or earlier, and allowed to rot on the ground. They were also found amongst the roots of grass.

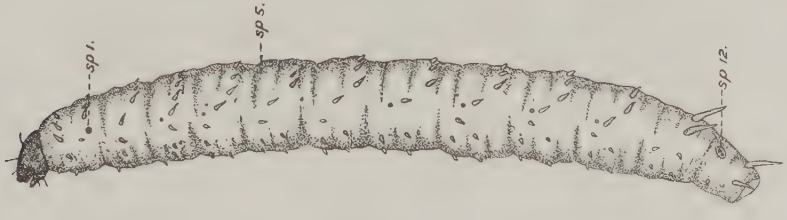

Fig. 3. Fully grown larva of *Bibio marci*, × 5; *sp.* 1, spiracle of first segment; *sp.* 12, spiracle of twelfth segment.

When fully grown the larva is from 20 to 24 mm. in length, and about 2·5 mm. in breadth. Its thickness is rather less than its breadth. The length of the head is about 1·5 mm. and its breadth a little less (fig. 3).

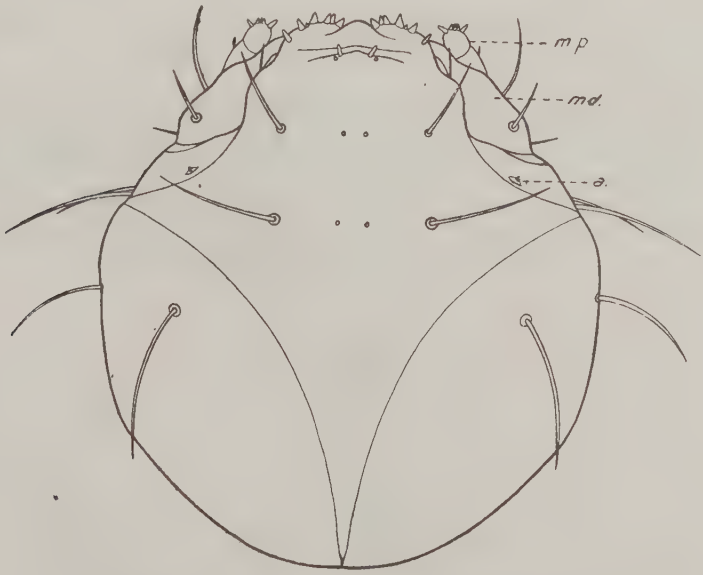

Fig. 4. Head of fully grown larva of *Bibio marci*, dorsal view, × 53; *a*, antenna; *md*, mandible; *mp*, maxillary palp.

The head (figs. 4, 5) is dark brown and shining, appearing almost black; the anterior half is somewhat darker in colour than the posterior and bears several long setae. The form of the mouth-parts and antennae is shown in figs. 6–9. The

antennae are exceedingly small and inconspicuous, being situated just above the bases of the mandibles. The structures which were previously considered to be the antennae (6) are lateral protuberances of the labrum.

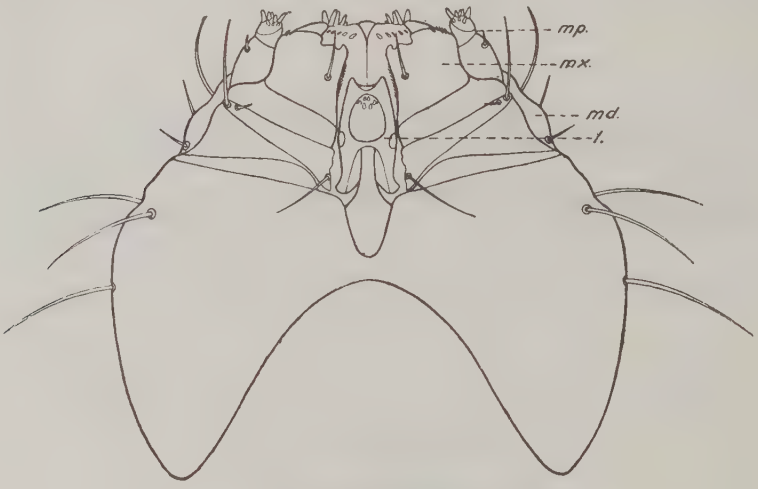

Fig. 5. Head of fully grown larva of *Bibio marci*, ventral view, × 53; *l*, labium; *md*, mandible; *mp*, maxillary palp; *mx*, maxilla.

The body is nearly cylindrical, but somewhat flattened dorso-ventrally, and normally is slightly curved, the ventral surface being concave. The body is divided into twelve segments, of which the first is the longest. It bears ten pairs of spiracles, which are situated a pair on each segment except the second and eleventh, and project slightly from the body. The spiracles on the first segment are about twice the size of those on segments 3 to 10, and those on segment 12 are about four times the size of those on segments 3 to 10, and each one has two openings.

Fig. 6. Antenna of larva of *Bibio marci*, × 580.

Each segment bears a number of stout conical processes, which are arranged more or less in rows, on both the dorsal and ventral surfaces, the more lateral processes in the rows being usually at least twice as long as the median ones. The arrangement of these processes does not appear to vary in the different species of *Bibio* which have so far been examined.

The spiracles of the first segment are situated laterally near the posterior boundary of the segment. Dorsally the segment bears two rows of processes, each row containing eight processes, the lateral processes of the second row being slightly

Fig. 7. Right mandible of larva of *Bibio marci*, ventral view, × 100.

Fig. 8. Right maxilla of larva of *Bibio marci*, ventral view, × 100.

displaced forwards by the spiracle. Ventrally the segment bears three incomplete rows. The first row consists of two processes; the second of four, one pair near the median line and the other pair lateral; in the third row there are four processes.

The second segment, which has no spiracles, bears a row of eight processes dorsally and another row of eight processes ventrally; the median pair in the latter row is situated nearer to the anterior margin of the segment than the remainder.

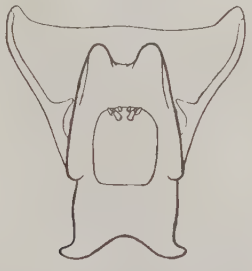

Fig. 9. Labium of larva of *Bibio marci*, ventral view, × 100.

The third segment bears a pair of spiracles laterally towards its anterior margin; dorsally it bears a row of eight processes, and ventrally a similar number, of which the middle pair is placed forwards as on the second segment.

The fourth segment bears a pair of spiracles in a similar position to those on the third segment. Dorsally this segment bears a row of eight processes, the lateral

pair being slightly nearer the anterior end than the remainder. On its ventral surface this segment bears two rows of processes, the first row containing six and the second four. The segments five to ten are similar to the fourth segment.

On the dorsal surface of the eleventh segment there is a row of six large processes near its posterior margin, of which the median pair is the largest. There is a single lateral process on each side near the anterior border of the segment and on the ventral side there are six processes.

The twelfth segment bears a pair of large spiracles anteriorly, which are placed in a more dorsal position than those on the other segments. Posteriorly it bears a row of four large dorsal processes, the median pair being the largest on the body. On the ventral surface of this segment there is a single pair of processes.

Fig. 10. Portion of cuticle of *Bibio marci* larva from dorsal surface of fourth segment; *a*, lateral view; *b*, surface view; the arrows directed anteriorly; × 330.

The cuticle with which the body is covered bears many small scale-like structures, which are packed especially closely together on the processes. The largest of these scales bear stout backwardly-directed spines of a darker colour than the remainder of the cuticle (fig. 10). The scales on the first, second and third segments, and some on the ventral surface of the twelfth segment, bear from one to four spines, and those on the remaining segments usually carry a single stout spine, but a second more slender spine is present on certain of the scales. The scales on the base of the processes all carry several spines, but those on the upper part have only a single spine.

The alimentary canal (fig. 11) takes an almost straight course through the body, but has a loop near the posterior end, in the hind gut. The largest part of the alimentary canal is the mesenteron, which bears three large caeca at its anterior end, one lying on each side and the third, which is the largest, placed ventrally.

The four Malpighian tubes join the alimentary canal at the junction of the mesenteron and hind gut, entering the canal by a short common duct on the dorsal side. There is no posterior caecum such as is found in connection with the alimentary canal of *Bibio johannis*.

Fig. 11. Alimentary canal of larva of *Bibio marci*, lateral view, × 5; *c*, caeca; M, Malpighian tubes; *oe*, oesophagus.

Pupa.

Elongate, cylindrical, tapering gently to posterior end, abruptly at anterior end. Completely free from larval skin. Colour at first white, head and thorax of imago showing dark through cuticle later. Length from head to tip of abdomen, ♂, 12·5 mm.; ♀, 15 mm. (fig. 12). Head with very slight, blunt, anterior, median process; a slight median dorsal ridge extending from the anterior median process to posterior margin of thorax, dehiscence for emergence of imago occurring along this ridge. Antennae extremely short, arising between bases of eyes, extending laterally over eyes. In the males, eyes large and protruding; in female, smaller and less conspicuous. Labium elongate, semicircular; labial palpi elongate, conical, extending laterally. Dorsally, most of head covered by prothorax, only eyes of male visible.

Thorax strongly arched dorsally. Pair of thoracic spiracles slightly projecting laterally. Tibiae and tarsi of fore legs extending from side of eyes level with antennae to anterior margin of second abdominal segment, with tarsi in apposition along median line. Second and third pairs of legs parallel to first, all except tibiae and first and last tarsal segments of second and last tarsal segment of third, covered by wings ; last tarsal segments appearing posterior to those of first leg, and those of each pair in contact along median line.

Fig. 12. Pupa of *Bibio marci*, ♂, ×5.

Abdomen nine-segmented ; length of segments in proportion 7, 10, 11, 12, 12, 11, 10, 9, 9 ; width of segments decreasing gradually towards posterior end. Cuticle with many fine wrinkles, mainly transverse ; on abdominal segments, dorsally and ventrally, bearing numerous spines similar to, but less stout than, those of larva, occurring singly or in groups of two to four, on slight swellings of cuticle. Terminal segment (fig. 13) bluntly conical, bearing a pair of stout, dark brown, sharply pointed processes at the posterior end, directed posteriorly and outwardly, and a pair of rounded papillae. All segments except eighth bearing a pair of slightly projecting spiracles laterally, towards the anterior margin of the segment.

Fig. 13. Posterior extremity of pupa of *Bibio marci*, ♂ dorsal view, × 18.

Bibio lacteipennis, Ztt.

A number of larvae which proved to be those of *Bibio lacteipennis*, Ztt., were found in a plant pot at Withington, Manchester, during February 1918. The larvae were kept in some of the same soil, which was a rich leaf-mould in which bulbs had been grown, in the laboratory, and the first pupa was seen on 23rd March, and the first adult appeared on 13th April.

Larva.

It is proposed to point out the differences between the larva of this species and that of *Bibio marci*, L., which has been described above.

The most obvious differences between these two species are the smaller size of the larva of *B. lacteipennis* and the fact that the processes on its body are relatively more slender. The number and arrangement of the processes on all the segments is the same in both species.

The most striking difference is exhibited in the cuticle. In both species the cuticle of the full-grown larva bears a great number of small, irregularly-shaped, scale-like structures. In *B. marci* the largest of these scales bear one stout spine, while in *B. lacteipennis* (fig. 14) the scales are much less well developed, and only those on the processes, and on the anterior part of the ventral side of the first segment of the body, bear these spines. The latter are, moreover, less stout than those of *B. marci*, and there do not seem to be more than two on any scale. On the ventral surface of the twelfth segment a few of the scales bear single, long, stout spines.

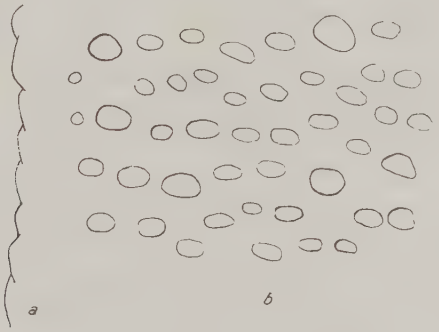

Fig. 14. Portion of cuticle of larva of *Bibio lacteipennis* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

The only apparent difference in the mouth-parts is the presence of a slight median projection between the two processes at the anterior end of the submentum.

The larva bears a pair of protrusible pseudopod-like structures at the end of the twelfth segment, which are relatively larger and better developed than is the case in *B. marci*.

The alimentary canal, Malpighian tubes and caeca appear to be similar to those of *B. marci*, and there is no posterior caecum.

The length of the full-grown larva is about 15 mm.

Pupa.

The pupa of *Bibio lacteipennis* bears a considerable resemblance to that of *B. marci*. It is distinguished from the latter by its smaller size and the somewhat greater development of the median process at the anterior end. The male pupa bears a pair of small, blunt processes, slightly ventral to the median process and situated on the anterior portion of the eyes. Length of pupa 7 to 7·5 mm.

Bibio venosus, Mg.

Larva.

A few larvae of this species were found in leaf-mould at Brockenhurst on 22nd March 1920, but unfortunately before they could be thoroughly examined they had all pupated.

The mouth-parts do not show any noticeable difference from those of *Bibio marci*, and the number and arrangement of the spiracles and processes is similar. With this larva again, as in the case of *B. lacteipennis*, the chief difference from *B. marci* is in the scales on the cuticle. As in *B. lacteipennis*, these scales are very slightly developed and do not bear spines, except those on the twelfth segment

and occasional ones on other segments, which bear a single, short, blunt spine. The scales in this larva are much more regular and are placed more closely together than in any other species so far examined (fig. 15).

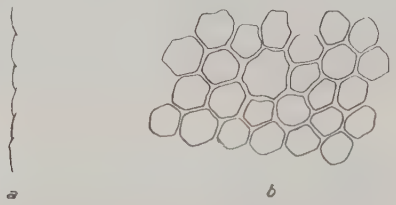

Fig. 15. Portion of cuticle of larva of *Bibio venosus* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

Pupa.

This pupa again bears a considerable resemblance to that of *B. marci*, from which it also differs in its smaller size; in the greater development of the process at the anterior end, which is slightly larger than that of *B. lacteipennis*; and in the presence in the male of a pair of similar blunt processes on the anterior portion of the eyes. The eyes in the male of this species are rather smaller than in the two species previously described. Length of pupa 10 to 11·5 mm. In the laboratory the pupal state lasted 19 days.

Differences between Larvae of various Species.

In the foregoing descriptions of *Bibio* larvae it will be noticed that attention is drawn to the differences in the cuticular structures in the different species dealt with. These differences seem so far to be sufficiently distinct and regular to give

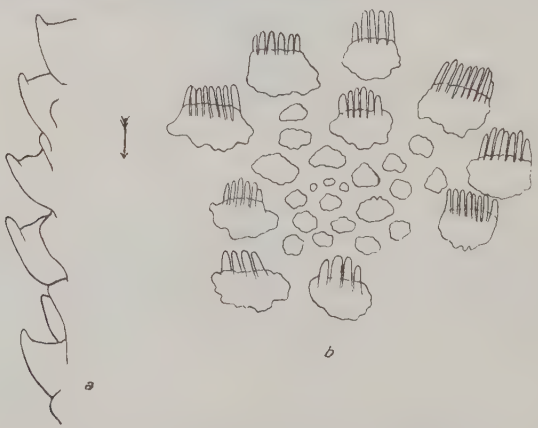

Fig. 16. Portion of cuticle of larva of *Bibio johannis* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

a ready means of distinguishing between the species in the larval state. There are many other species of *Bibio*, the larvae of which have not yet been examined, but it is possible that some such distinction may hold good throughout.

In addition to the three species described above, larvae of *Bibio johannis*, L. (fig. 16), have been examined, and also larvae believed to be those of *B. pomonae*, F. (fig. 17), but the latter were not definitely identified in the adult state. As will be seen from the illustrations, these two species are quite distinct from the other species figured.

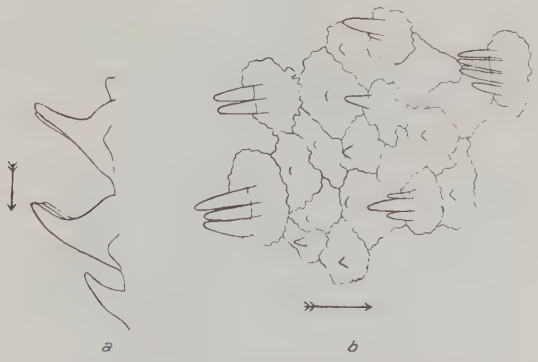

Fig. 17. Portion of cuticle of larva of *Bibio pomonae* from dorsal surface of fourth segment : *a*, lateral view ; *b*, vertical view ; the arrows directed anteriorly ; × 330.

The alimentary canal also varies in some of the species examined, that of *B. marci* and *B. lacteipennis* being without the posterior caecum which is present in the canal of *B. johannis*. This posterior caecum is also absent, according to Keilin (4), from the alimentary canal of *B. hortulanus*, L. The labium also shows slight variations in different species.

Parasites of Bibionid Larvae.

Very few parasites of the BIBIONIDAE are known. In addition to the mite and nematode recorded by Lyonet, Keilin (4) mentions the Gregarine *Schneideria mucronata*, Leger, occurring in the mid-gut and anterior caeca of Bibionid larvae, and also a bacterial disease. He further mentions a Microsporidian, probably a *Glugea*, which invades the epithelial cells of the mid-gut and caeca of Scatopsid larvae.

Sorauer (7) gives *Agyrtes bicolor* as a parasite of the larvae of *Scatopse*.

A Gregarine, probably the *Schneideria* mentioned by Keilin, was found in the posterior caecum of a *Dilophus febrilis* larva, and in the same larva two cysts full of spores were found free in the body. Another parasite, probably the *Glugea* mentioned above, was found infesting the epithelium of the alimentary canal in a *Bibio johannis* larva.

In addition to these a Dipterous parasite was met with in connection with *Bibio marci* larvae. This was the Phorid *Hypocera incrassata*, Mg. The fully grown larvae emerged from the *B. marci* larvae when the latter were about to pupate, and almost immediately entered the pupal state. Only a single parasite was observed in each larva attacked.

Additions to Literature since 1917.

In 1917 an account of the larva and pupa of *Bibio johannis* was published, in which the literature up to that date was referred to. The following publications have appeared since that date.

A brief account, with figures of the larva, pupa and adult, of *Plecia fulvicollis*, F., an Indian Bibionid, has been published (3). Keilin (4) has given a short account of the alimentary canal in *Scatopse notata*, *Bibio hortulanus* and *Dilophus febrilis*. That of *B. hortulanus* resembles the alimentary canal of *B. marci* in the absence of the posterior caecum, which however is present in a well developed state in *Dilophus febrilis*.

A few additional records of damage to crops by Bibionid larvae have been published also. Carpenter (1) records *Bibio* larvae as having caused much damage in wheat fields in Co. Cavan, Ireland, in March 1918, by eating the roots of the plants; and *Bibio marci* larvae are reported to have damaged potatoes in a "pit" in Co. Louth, in October 1916.

Molz (5) records *Bibio hortulanus* larvae as damaging potatoes near Halle in September 1918 by eating beneath the skin. It was noticed that only parts of the field which had been treated with stable manure were infested. Afterwards winter wheat was sown and larvae were found to be feeding on the seed. In experiments it was found that the larvae attacked the seed at the point of germination, and also that only potatoes which had previously been injured were attacked. Potato skins steeped in a 1 per cent. solution of arsenious acid were found to form an attractive and effective poison bait.

1. Carpenter, G. H. (1920). "Injurious Insects, etc., in Ireland during 1916, 1917 and 1918." Econ. Proc. Roy. Dub. Soc., ii, No. 15, Nov. 1920.
2. Curtis, J. (1844). "*Bibio marci*." Gardeners' Chronicle, 16th Nov. 1844, p. 764.
3. Fletcher, T. B. (1919). "Second Hundred Notes on Indian Insects." Agric. Research Inst., Pusa, Bull. 89, p. 58.
4. Keilin, D. (1919). "On the Alimentary Canal and its Appendages in the Larvae of Scatopsidae and Bibionidae (Diptera Nematocera), with some Remarks on the Parasites of these Larvae." Ent. Monthly Mag. (3) v, pp. 92–96.
5. Molz, E. (1920). "Weitere Beiträge zur Kenntnis der Gartenhaarmücke (*Bibio hortulanus*, L.)." Zeitschr. angew Entom. Berlin, vii, No. 1, Sept. 1920. pp. 92–96, 3 figs. (Abstract in *Rev. App. Ent.*, 1921, p. 1).
6. Morris, H. M. (1917). "The larval and pupal stages of *Bibio johannis*, L." Ann. App. Biol. iv, 3, pp. 91–114.
7. Sorauer, P. (1913). Handbuch der Pflanzenkrankheiten, iii, p. 458.

Fig. 1. A typical case of "Simulium disease."

Fig. 2. Chemosit River flowing through forest heavily infested with *Simulium*.

Fig. 1. Dense thorn forest heavily infested with *Simulium*, Lumbwa Reserve, Kenya Colony.

Fig. 2. Thin thorn forest, adjoining that in Fig. 1, lightly infested with *Simulium*.

TRYPANOSOMIASIS IN THE ABSENCE OF TSETSES, AND A HUMAN DISEASE POSSIBLY CARRIED BY SIMULIUM IN KENYA COLONY.

By F. W. Dry, M.Sc.,

Recently Assistant Government Entomologist, Kenya Colony.

(Plates VII & VIII).

This is an account of two different inquiries carried out on the same safari in the Lumbwa country of Kenya Colony early in 1920. The problems are of the same type, the suspected transmission of disease by blood-sucking flies, and the second investigation arose out of the first. It therefore seems best to deal with them both in a single paper.

In March 1920, in the absence of my Chief, Mr. T. J. Anderson, I was asked to make a fly survey in the neighbourhood of a farm in the Kericho district where cases of trypanosomiasis had been demonstrated. I arrived at this farm on 25th March. The blood-sucking flies collected are listed below. As was anticipated, the altitude being about 6,300 ft., and there being no records of tsetse-fly anywhere near, none was found. I was then fortunate in receiving information from Mr. Ian Q. Orchardson, the pioneer settler of the Kericho district, about a small blood-sucking fly to be found in the forest in part of the Lumbwa Reserve. The bites of this fly, he told me, are believed by the Lumbwa to be the cause of a disease from which some of the inhabitants of that region suffer. He further suspected that this fly might transmit a disease of cattle. Accordingly, on 7th April, I proceeded into the area about which he had told me in the Lumbwa Reserve, also crossing the Kipsoni into adjacent country of the Kisii Reserve. The fly proved to be a *Simulium*. I satisfied myself that it could not be regarded as the transmitting agent of any cattle disease, but did obtain evidence which shows that the belief of the Lumbwa calls for further investigation. On 29th April, I returned to the farm near Kericho, to search for *Simulium* there, but failed to find it, staying there until 3rd May.

I. Possible Transmission of Trypanosomiasis in the Absence of Tsetses.

The presence of trypanosomiasis on the farm near Kericho was demonstrated from blood-slides taken by the late Captain J. Cameron, Veterinary Officer, and examined by Mr. W. Kearney, Assistant Veterinary Pathologist. His diagnosis of the type of trypanosome was confirmed by Mr. R. E. Montgomery, now Veterinary Advisor in Uganda, who wrote to Mr. Kearney in January 1920 :—" On purely morphological features, the trypanosomes . . . . . are recognisable as *Tr. uniforme*. The bold body, slightly developed, undulating membrane, short, free flagellum, distinct blepharoplast and clear cytoplasm all point to this species, or a near relative of the *vivax* group."

The farm where the outbreak occurred was a new one, and all the cattle on the farm, other than those of native squatters, were working oxen which had been bought and brought on to the farm towards the end of 1919 or early in 1920.

In 1919 there had been no deaths of oxen, apart from one animal which died after an accident, but from early January up to my arrival there had been a high mortality, and trypanosomiasis had been demonstrated from blood slides in some cases. Particulars about the losses up to the time of my visit are as follows :—

Total number of European owned oxen	63
Deaths :—	
Trypanosomiasis proved by blood-slides	2
Not due to any disease	2
Cause not proved	14

Ten cases of trypanosomiasis were proved from blood-slides, all taken previous to the 6th April, and eight of the oxen were still alive at the time of my visit.

After my visit the mortality ceased. No more cases of the disease were detected, and all animals proved to be infected were slaughtered in order to bring the outbreak to a close.

It should here be mentioned that two farmers resident for some years in the district told me that when cattle are brought from other parts of the country to poor grazing of the sort on this farm and worked hard, as the oxen had been, there is great risk of loss. This, it seemed, might be the explanation of some of the deaths. With the fact, however, that, in all, ten cases of trypanosomiasis were proved, and that no other disease had been demonstrated on the farm, the presumption certainly is that some of the fourteen deaths of which the cause was not known were due to trypanosomiasis.

There were no signs of the disease amongst the small number of cattle owned by Lumbwa on the farm. The European and native owned animals were kept away from each other.

The European owned oxen had all been bought from dealers, two European and two Indian. Those obtained from the European dealers had been through the Kibigori Quarantine Station, to which animals were taken from widely separated sources; those from Indians had probably come out of the Lumbwa Reserve.

Of the ten animals proved to have trypanosomiasis two had been purchased from one European dealer, two from the other, and the remainder from one or other of the two Indian dealers. A sufficiently accurate record had not been kept to make it certain whether animals which had the disease had come from one Indian dealer or from both, but the partner on the farm in charge of the cattle felt almost certain that it was from both. At any rate, animals from three out of the four sources had trypanosomiasis, and though there is just a chance that both the European dealers had bought cattle from the same mob from Kibigori, the number of distinct sources from which animals proved to have trypanosomiasis had come is at least two, though it may be four.

Another point to be noted is that the second animal which was proved to have the disease came on to the farm early in February, having been purchased from one European dealer, after the death, on 1st February, of the first animal proved to have the disease, which had been bought from the other European dealer.

One piece of information given to me must now just be mentioned about the possible presence of trypanosomiasis cases other than oxen on the farm. A Dutch manager who had left the farm had had two donkeys. One donkey is believed to have died or been killed on the farm in November or December of 1919. The other had been given to a Kericho resident and had subsequently died. This manager was stated to have thought that the donkeys had trypanosomiasis. This evidence is not of a definite description, but is recorded because Captain Cameron inclined to the view that it might have been in these donkeys that the disease was brought on to the farm.

I collected blood-sucking flies on this farm and on neighbouring land, near to the river known at different parts of its course on the farm boundary as the Saosa, the Dimbilitch, and the Kitho, near to small tributary streams, and on the grazing grounds of the cattle, which were then being kept away from the river. The blood-sucking fly fauna could not be considered a striking one. All such flies captured belonged to the genera *Haematopota* and *Stomoxys*. *Stomoxys* were chiefly captured on grazing oxen, often being present in large numbers, while almost all the *Haematopota* were taken near to the river.

While in the Lumbwa and Kisii Reserves I was collecting blood-sucking flies at various lower points on the same river system, as far as a point on the Sondo River about fifteen miles in a direct line from the farm, and with the exception of a *Simulium*, to be referred to shortly, the only specimen taken of a fly of any additional genus was a single individual of *Tabanus taeniola*, P. de B., var. *variatus*, Walk., captured in the Lumbwa Reserve about ten miles due west of the farm. While it is not impossible that that fly might be taken on the farm, it can hardly be common there. The Lumbwa herd-boys on the farm told me that my captures included specimens of all the blood-sucking flies which they knew to be there.

The cattle on the farm were not dipped and some ticks were collected from them.

The species of blood-sucking flies and ticks taken were the following :—

Haematopota similis, Ric.—10 ♀♀.
,, *hirta*, Ric.—2 ♀♀.
,, *brunnescens*, Ric.—11 ♀♀.
,, *alluaudi*, Surc.—5 ♀♀.
,, *ugandae*, Ric.—28 ♀♀.
Stomoxys calcitrans, L.—15 ♂♂, 22 ♀♀.
,, *varipes*, Bezzi—3 ♀♀.
,, *nigra*, Macq.—1 ♀.
Amblyomma variegatum, F.
Boophilus sp.

Mr. Orchardson told me of an extensive area of thick thorn forest in the Chemosit River district of the Lumbwa Reserve which the Lumbwa leave almost uninhabited owing to its being infested with a fly which proved to be a *Simulium*. The belief of the Lumbwa, about which he told me, that the bites of this fly cause a disease of human beings will be discussed directly. He further suspected that this fly might be the carrier of some disease of cattle. In 1917 he and a neighbour carted maize to their farms near Kericho from Litun, and outspanned their oxen just off the Sotik Road near to the Chemosit and Jamji Rivers. Afterwards some of the oxen used in this work died, each planter losing about half a dozen animals. "These," he said, "gradually faded away and died." Some were ill for weeks, some for months. They were not seen by any veterinary officer. Now there is a considerable area of thorn forest on and near the farm where the outbreak of trypanosomiasis had occurred, so this was a suggestion to be followed up.

My inquiry, however, yielded negative results, for :—

(*a*) Those Lumbwa who live in the infested area keep cattle. One young man had come two years ago from a district clear of *Simulium* in order to graze his father's cattle in the infested country, for much of the grazing is good.

(*b*) The people told me that *Simulium* bites cattle, sheep and goats, but they said that it does not give the animals any disease.

(*c*) It was pointed out to me by Mr. C. M. Dobbs, the District Commissioner at Kericho, that cattle are frequently outspanned just off the Sotik Road in the same place as those of Mr. Orchardson and his neighbour, but he had not heard of any other cases of disease supposed to have been contracted there like that of which Mr. Orchardson had spoken.

(*d*) I failed to find *Simulium* so far east as the Sotik Road, the nearest point where a specimen was captured, and that at a place where *Simulium* was not numerous, being a mile and a half to the west, though it is not impossible that the fly may occur on the road in small numbers.

After this visit to the Reserves I returned to the farm of the outbreak and again collected blood-sucking flies there and in the thick thorn forest on adjacent land,

searching especially for *Simulium* but finding none. Inquiries were made from a large number of natives, who replied, either that they knew nothing at all about the fly, or that they knew of it near the Chemosit River.

Simulium was therefore not a factor in the presence or transmission of trypanosomiasis on the farm where this outbreak had occurred.

The evidence recorded above, combined with the fact that no other outbreak of trypanosomiasis was recorded in the district, points to the probability that the disease was transmitted on the farm to healthy animals from one or more animals which were infected when they came on to the farm. If that be so, suspicion would fall first on *Stomoxys*.

II. Possible Connection of *Simulium* with a Disease of Human Beings.

The Lumbwa name for this *Simulium* is "kekonjek." A place infested with *Simulium* is spoken of as "kapkekonjek." The insect has been identified by Mr. F. W. Edwards, of the British Museum, as *Simulium neavei*, Roubaud.

The badly infested country, so far as I was able to ascertain from my own observations and from inquiries from the Lumbwa, is covered with dense forest, mostly of thorn trees, white and red, with occasional open spaces (see Plates vii and viii). It is well watered, and it is unlikely that there is any point within that area much more than two miles from some stream, large or small. About three miles below the junction of the Chemosit and Kipsoni Rivers one fly was captured, this being the lowest point reached on that river on the trip; *Simulium* was present there in only small numbers and it was evident that, lower down, neither the Lumbwa on the right bank of the river, nor the Kisii on the left, paid any attention to the fly. It was also taken in small numbers in a tributary valley of the Sondo River on the left bank a mile from the Sondo; in this valley there were scattered clumps of trees but not continuous forest.

The flies are appreciably less numerous in thin than in thick forest (see Plate viii), and while present in the middle of open spaces—say a quarter of a mile in diameter—are there distinctly less numerous than in the forest. This falling off in numbers as one gets away from dense forest is quite a sudden one.

The flies are active, the Lumbwa told me, and my own observations are consistent with what they said, from about seven o'clock in the morning until five in the afternoon, and especially so in the afternoon. Very little is seen of them when rain is falling, and I was told, and from my own collecting believe it to be so, that the flies are not so active in intense sunshine as when the sun is less bright. They pay little attention to people on the march, but if one remains still in infested country they appear immediately. They bite very readily and often raise half-inch wheals, a drop of blood frequently exuding from the puncture. In badly-infested forest a person sitting with a bare back and allowing the flies to do as they liked would probably be bitten once a minute at the very least.

It is the accepted belief of the Lumbwa and Kisii amongst whom I moved, that a disease is caused by the bites of these flies, the chief symptom being that the skin is in folds (Plate vii, fig. 1). It would seem that these folds appear first on the small of the back, but sometimes the skin higher up the back, and more rarely that of the front and sides of the body was seen to be affected in the same way, while occasionally, though this was only so with elderly people, the condition would extend to the arms and legs. Sometimes the skin was spotty, as shown in the photograph, and occasional cases were shown to me as *Simulium* disease in which spots, but no folding, were present.. People with the affection scratch themselves a great deal.

Many of the affected people that I saw were able to carry on their usual activities, but some looked to be in quite a feeble condition. I asked one young man if he

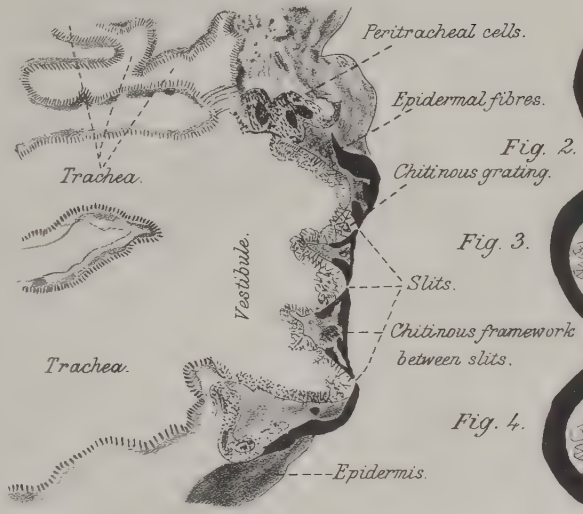

Fig. 1.

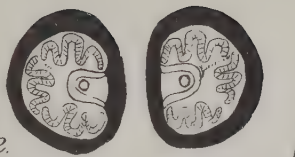

Fig. 2.

Fig. 3.

Fig. 4.

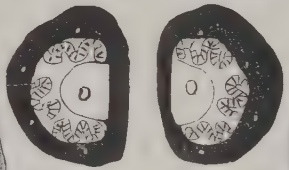

Fig. 5.

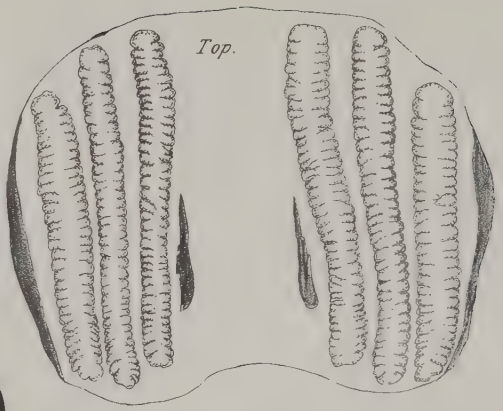

Fig. 6.

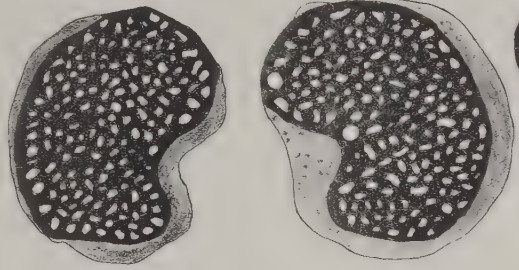

Fig. 7.

Fig. 8.

Huth, London.

SPIRACLES OF LARVAE OF MYIASIS-PRODUCING FLIES.

Fig. 9.

Fig. 10.

Fig. 11

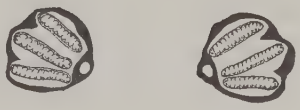

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 16.

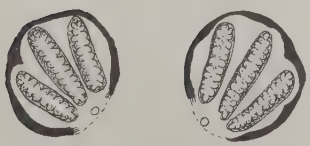

Fig. 17.

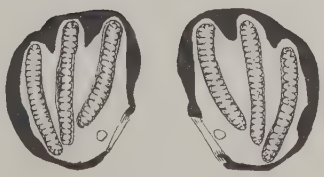

Fig. 18.

Huth, London.

SPIRACLES OF LARVAE OF MYIASIS-PRODUCING FLIES.

could work properly, and those present laughed at my putting such a question to him. One man, the one shown in the photograph, I spoke of as " elder," and was told that he looked like an elder because of the disease, but was really only a " warrior."

Poor sight, or even blindness, is stated by the Lumbwa to be caused by the disease occasionally, but two people with the skin affection who had bad sight looked to me to be suffering from cataract.

The youngest person with the skin affection that I saw was a boy perhaps sixteen years old, but I was told that quite small children sometimes had it. Young people may recover from the disease, and I met three people who said they had done so ; one of them, now an elder, said he had been ill for five years, and recovered ten years ago. With old people, I gathered, the condition always persists until death. Some people told me that they had had the disease for thirty years or more. It seems unlikely that the disease is the cause of death.

While the Lumbwa are convinced that this disease is caused by the bites of *Simulium*, they do not believe that it can be caused by a single bite or by only a few bites. I was told repeatedly that a person living a short time, say a fortnight, in badly infested country, would not get the disease, and people that I met have lived there much longer than that without contracting it. Again, I was told that while the disease could be contracted by herding animals in infested country day after day, it would be safe for a person to herd them there occasionally. The Lumbwa have no hesitation in going into infested country now and again to hunt, pick vegetables, or search for honey, and a very well-marked track runs right through the forest between the well-inhabited districts to the north and to the south of the infested forest on both sides of the Chemosit. And further, just away from the edge of infested forest, and in country where I took *Simulium* in small numbers, many Lumbwa were living, and considered themselves to be running only very slight risk of getting the disease. *Simulium*, the Lumbwa told me, does not enter houses.

Part of this slightly infested area adjacent to badly infested forest, the Lumbwa told me, they had cleared of thick forest, thus, they said, themselves converting it from unsafe into reasonably safe country. Another obvious way of avoiding the bites of the fly is the wearing of European clothes. I was scarcely bitten at all myself while moving in infested country for three weeks.

The total number of people that I saw who were said to have the disease at the time of my visit, not counting one Kisii, who possibly had the disease and who will be mentioned again shortly, was twenty-three. Seven other cases I heard of, but did not see, and probably some others exist. Of these twenty-three people, twelve were male and eleven female. Roughly speaking, eleven were young and twelve old. Of the twenty-three, eight were living in the forest at the time of my visit and at least six had lived there previously, making their homes elsewhere after getting the disease. The remainder had lived near to infested forest and had often gone into the forest. I was told that cases of this disease were not to be found in country away from the vicinity of infested forest. It was said that if a person with the disease attempted to settle in country other than adjacent to the infested forest, he would not be allowed to do so by the other inhabitants.

The one apparent exception which I came across, to the coincidence of distribution of the disease and *Simulium*, was a Kisii elder whose skin showed both folds and spots, but who was stated never to have lived in infested country.

Special reference must be made to two settlements in clear spaces in the infested forest, areas in which the fly could be found in fair numbers, and both surrounded by heavily infested forest, where I inquired, as far as I was able, after the health of those who were living there. There may have been other people that I did not see or hear about, but eight adults that I saw who had lived there for more than two years all had the disease, though one other old resident, a man that I did not succeed in

seeing, was stated probably not to have the disease. Six other adults who had lived there from a few weeks to two years were healthy. A number of children, too, some of whom had lived there all their lives, and might be as old as ten, were all free from the disease ; they do not go into the forest nearly as often as grown-up people.

These facts, therefore, do indicate coincidence of distribution of the disease and *Simulium*.

One piece of tribal history that I learnt from both the Lumbwa and Kisii throws light on the way in which *Simulium* is regarded by these two peoples. Formerly the country badly infested with *Simulium*, which is now in the Lumbwa Reserve, was occupied in its western part by the Kisii, the eastern part being left uninhabited out of mutual fear, for in those days the relations between the two tribes were by no means peaceful. Some time before the area came under British influence, possibly, though such information given by natives must be considered of doubtful accuracy, about thirty years prior to the present day, the Lumbwa succeeded in driving out the Kisii from the infested country, where they proceeded to settle, and established themselves, too, on the left bank of the Kipsoni and Sondo, but these Lumbwa were moved back across the river by the British Government.

I had a lengthy conversation with some of the Kisii, now old men, but warriors at the time of the war, who had formerly lived in the infested country. They told me that they knew the fly and the disease and believed the one to be the cause of the other. The Kisii had not hesitated to live in that country on account of the disease. Only a few of their people, they said, had had the disease. The land, they said, and the Lumbwa had told me the same, was excellent for crops and the grazing good. Wishing to know how seriously they regarded the disease, I asked them if they would go back to the *Simulium* country if they could. They replied, " Certainly," and asked if I had been sent to arrange for their return.

After that war the Lumbwa settled in the conquered country in considerable numbers, but very soon found they were getting the disease, when the great majority left the district. A few of the Lumbwa living in infested country and having the disease were amongst the original settlers and a few more have settled there more recently, but the total number of inhabitants, in an area of perhaps 20,000 acres, is small in the extreme.

I obtained blood-slides from three Lumbwa men who had lived in the infested country ever since it had become Lumbwa territory, and said they had had the disease for about thirty years. These slides Dr. Clearkin, Acting Senior Bacteriologist, afterwards kindly examined, finding about 20 per cent. of eosinophilia in the blood from each of the three individuals.

Dr. Clearkin hopes to find an opportunity of visiting the Lumbwa country to investigate the disease. The District Commissioner has tried to persuade some of the Lumbwa having the disease to come to Nairobi in order to be examined, but they have declined to leave their Reserve.

NOTES ON THE MYIASIS-PRODUCING DIPTERA OF MAN AND ANIMALS.

By Major W. S. Patton, M.B., F.E.S., I.M.S. (rtd.),

Lecturer on Entomology and Parasitology, Edinburgh University.

(Plates V & VI.)

Myiasis has been defined by Austen as follows :—"There remains yet a third category of flies, chiefly belonging to the great Family Muscidae, the larval stage of which is sometimes actually passed in the living human body, the presence of the larvae in the various organs and tissues, and the disorders or destruction of tissue caused thereby, being comprehensively known as Myiasis." It will be noted that this definition only refers to the larval stages of flies, but as the eggs, and in one case at least, pupae and adults, may be found in the human body, and as myiasis is a common condition in many animals, the definition may now be amplified as follows :—The condition or conditions, resulting from the invasion of the tissues and organs of man and other animals by all the stages of the Diptera.

In the latest edition of Castellani and Chalmer's "Manual of Tropical Medicine" (1919) species of flies belonging to no less than ten families have been incriminated as causing myiasis in man ; there is very little doubt, however, that the identification of some of the species is more than doubtful. These lists do not even include the most important myiasis-producing Calliphorine of Africa, *Chrysomyia bezziana*, Vill., so that the information given on this subject must be considered very incomplete. This is chiefly due to the fact that it is difficult to breed the flies from larvae recovered from cases of myiasis, in order to be sure of the identity of the species, and unfortunately in most cases identification of species by larvae alone is not yet possible. Although specimens of larvae are doubtless plentiful in museums and private collections, their respective adults, accurately identified, are, on the other hand, scarce.

Quite recently I undertook an inquiry into the larvae of the myiasis-producing Diptera of India in order to discover to what species of flies they belonged. Through the kindness of the Indian Research Fund Association I was able to issue a printed appeal, with detailed instructions for collecting living larvae, to every medical and veterinary officer in India, Burma, Assam and Ceylon, and in a very short time large numbers of living larvae and puparia were received from all over this area, and hundreds of flies were bred out and accurately identified. The results of this inquiry have demonstrated how little we know of the Indian species whose larvae cause myiasis in man and animals. The following species were found to be those which usually cause myiasis in man and animals in India :—

(1). *Chrysomyia* (*Pycnosoma*) *bezziana*, Vill.—This proves to be the common myiasis-producing Calliphorine of India and adjacent parts. Its larvae cause rhinal, oral, ocular, aural, vaginal and cutaneous myiasis in man and animals, but its larvae never cause intestinal myiasis.

(2). *Chrysomyia megacephala*, Fabr. (*dux*, Esch.) and *Lucilia argyricephala*, Fabr. (*serenissima*, Macq).—The larvae of both these species may be occasionally found in cases of myiasis in animals.

(3). *Sarcophaga* sp. incert.—This species, which it has not been possible to identify, as the larvae were sent to me preserved in spirit, occasionally causes cutaneous and intestinal myiasis in man. In the former cases the destruction of the tissues is very extensive.

(4). *Aphiochaeta xanthina*, Speiser (*ferruginea*, Brunetti), and *A. rufipes*, Meig.—These two Phorids commonly cause tissue and intestinal myiasis in man and animals in their larval stages.

During the course of this inquiry, which extended over more than a year, I gained a large amount of valuable information on such points as, how best to breed these flies from their larvae, how to preserve and send the larvae for further study and, most important of all, how to set about identifying the larvae and adults of blowflies in general, and the myiasis-producing species in particular. It is with the object of extending the inquiry to the study of the myiasis-producing flies from other parts of the world, particularly from Malaya, the Dutch East Indies, China, Japan, Australia and Tropical America, that I propose recording my notes in this paper. Although much valuable work has been done on the myiasis-producing Diptera of Africa by Rodhain, Bequaert, Roubaud and others, our information regarding the CALLIPHORINAE which parasitise man in their larval stages is still very imperfect. For instance, it is not known whether *Chrysomyia bezziana* deposits its eggs in human tissues in Africa, though its larvae are extremely common in human tissues in India. I would therefore ask all those who may have opportunities of collecting such material from man and animals to forward it to Dr. Guy A. K. Marshall, C.M.G., Director of the Imperial Bureau of Entomology, British Museum (Natural History), Cromwell Road, London, S.W. 7., who has kindly consented to receive it and forward it to me for further study. The results will be published from time to time in this Bulletin. I may say that as the identity and correct names of many of the common blowflies are at present hopelessly confused, I have decided to extend this study to the CALLIPHORINAE in general. Specimens of any blowflies and their larvae, particularly first stage larvae, and any of the larvae and adults of the OESTRIDAE will be most welcome. Most of the Indian material has already been collected, and is now being studied; material from the areas mentioned above would be of great value for comparative study. Those who wish to help in this inquiry will find full details of how to collect and breed blowflies in general, and the myiasis-producing species in particular, in these notes. I shall be glad to correspond with any observer who would like any further information on this subject.

The Classification of Myiasis-producing Diptera.

A reference to the recent literature on this subject shows that the myiasis-producing Diptera are mainly grouped according to the tissues or organs in which their larvae are found, so that we have such species as cause rhinal, oral, aural, ocular, tissue, and cavity myiasis. But such a Calliphorine as *Chrysomyia bezziana* will deposit its eggs in any of these organs or tissues, so that following this method of classification it would have to be placed in several of the groups.

Recently Bishopp has contributed a valuable article on this subject, grouping the species according to the methods of attack, his groups are as follows:—

(1). *Tissue-destroying forms.*—In this group are included those species whose larvae attack living animals secondarily, mainly breeding in the bodies of dead animals. Bishopp rightly places *Cochliomyia* (*Chrysomyia*) *macellaria*, the well-known screw-worm fly of Tropical America in this group, also such species as *Lucilia sericata*, and species of *Sarcophaga*. *Chrysomyia bezziana* would also have to be placed in this group, for its larvae are true tissue-destroyers, as anyone who has seen a scalp wound infested with its larvae will know. But this Calliphorine cannot be placed in the same group as *Cochliomyia macellaria*, *Lucilia sericata* and species of *Sarcophaga*, for the simple reason that it never breeds in dead tissues; it is a true specific myiasis-producing species, and the only known metallic Calliphorine which has this habit.

(2). *Subdermal migratory forms.*—Species, the larvae of which are true parasites of man and animals during the greater part of their lives, living beneath the skin,

and in the subcutaneous tissues; *Dermatobia hominis*, *Hypoderma bovis* and *Cordylobia anthropophaga* are good examples. *Chrysomyia bezziana* must also be placed in this group, for its larvae are true dermal parasites of man. I have had examples of its larvae sent me from such small skin punctures as are made in boring the lobes of the ears for ear-rings, and in small cuts on the skin. The only difference between a case of myiasis caused by the larvae of *Chrysomyia bezziana* and that of *Cordylobia anthropophaga* is that, in the former, it is a massed infection, while in that of the latter it is only one larva which causes the myiasis. In the former the tissues rapidly break down and suppurate, while in the latter they do not. Both are specific myiasis-producing Diptera.

(3). *Larvae infesting the intestinal and urogenital tracts.*—The larvae of these species feed, to a lesser or greater extent, on the food contained in these organs, especially in the gastro-intestinal tract. In this group Bishopp includes those species whose larvae accidentally find their way into the intestinal tract, such as the larvae of *Fannia canicularis* and those of many species of *Sarcophaga*, and those OESTRIDAE whose larvae live in the intestinal tract of animals. I should like to point out that two categories are here involved; in the one case, the larvae only accidentally pass into the gastro-intestinal tract, the species concerned normally breeding outside the human body, whereas in the case of the OESTRIDAE mentioned, the larvae can *only* live in special parts of the alimentary tract. Species with such distinct habits cannot be placed in the same group.

(4). *Forms infesting the head passages.*—In this group Bishopp includes those true parasites of man and animals, the larvae of which live in the nose and its accessory sinuses, the throat, etc. Here again, this group would have to include *Chrysomyia bezziana*, for its larvae also live in the nose and accessory sinuses, and are true human and animal parasites. In the one case the tissue destruction is not great, whereas in the other it is often extensive.

(5). *Blood-sucking forms.*—In this group Bishopp includes those species whose larvae are blood-suckers. Blood-sucking can, however, hardly be considered a form of myiasis, for then we would have to include in this group all the blood-sucking Diptera.

I have said enough to show that the various methods of grouping the myiasis-producing Diptera according to the tissues or organs attacked, or the methods of attack, are not satisfactory. I am of opinion that the subject is best considered from the standpoint of the habits of the flies themselves, which then naturally fall into three groups as follows:—

(1). Specific myiasis-producing Diptera.

(2). Semi-specific myiasis-producing Diptera.

(3). Accidental myiasis-producing Diptera.

I will now give a few notes on the adults, hosts, geographical distribution, etc., of the species belonging to the various groups, reserving the notes on all the larvae until their identification is dealt with.

Specific Myiasis-producing Diptera.

In this group I include all those Diptera whose larvae are found only in living tissues, the flies selecting a number of tissues or organs, or one particular organ, depending on the species, in which or near which to lay their eggs or deposit their larvae. The following species are included in this group:—*Chrysomyia bezziana*, *Cordylobia anthropophaga*, *C. rodhaini*, *Wohlfahrtia magnifica*, and all the OESTRIDAE.

Chrysomyia bezziana, Villeneuve.—As I have mentioned above, this species is the specific myiasis-producing Calliphorine of India, Burma, Assam, Ceylon and Africa. Its larvae are commonly found in the nose and accessory sinuses, the mouth,

ear, eye and vagina, and in sores, cuts, wounds and abscesses, in man and animals. As a result of the enquiry made in India, I received the larvae of this species from more than 170 cases of human and animal myiasis; not a single larva was sent from the intestinal tract. As this fly breeds only in living tissues it is rarely seen in nature, for it does not frequent places where most other blowflies may be seen, such as food stalls, refuse heaps, latrines, and about the bodies of dead animals. The female fly is attracted by any offensive discharge, and will then lay her eggs in a mass, varying in number from 380 to 500, on or near the tissues from which the discharge comes. A sore, wound, or a diseased organ, such as a nose from which there is an offensive discharge, is therefore a necessity. The larvae rapidly reach maturity, owing to the high body temperature and rich food, and when mature crawl out and pupate in the ground. It is very probable that the adults are flower-feeders, and that as the mature larva stores up a large amount of food in its fat-body, there is sufficient nutriment for the eggs to ripen, as in the case of the OESTRIDAE.

Chrysomyia bezziana is a well-known pest in Africa, where it has been recorded by Rovere, Bouet, Roubaud and Joyeux from the Belgian Congo, the Upper Ivory Coast and French Upper Guinea; by Jack from Rhodesia; and by Aders from Zanzibar. Curiously enough, in Africa its larvae have been recorded only from the tissues of the larger animals, chiefly cattle; so far as I am aware, they have never been found in human tissues.

In India the female *C. bezziana* may be readily confused with the female of *Chrysomyia megacephala*, F. (*dux*, Esch.); both species have yellow cheeks. In order to distinguish them with any certainty, it is necessary to examine the front and to note the following points:—The front of the female *megacephala* is more than one-third the width of the whole head, that of *bezziana* is distinctly less than one-third. The frontal stripe of *megacephala* is wider than that of *bezziana*, the sides appearing slightly convex along their outer margins; in *bezziana* the stripe is slightly browner and the sides are almost straight. The para-frontals in *megacephala* are wider and of a greyish yellow colour, those of *bezziana* being much more silvery. The ocular margin of *megacephala* is slightly concave, and the lower margin of the eye rounder than in *bezziana*. The vertical bristles of *megacephala* are better developed than those of *bezziana*. Lastly, and this is perhaps the most valuable distinguishing character, the squamae of *megacephala* are of a dirty yellow colour, while those of *bezziana* are waxy white; in both they are covered with dark hairs.

The male *megacephala* can be readily distinguished from the male *bezziana* by its bright red eyes, and the area of large lenses occupying about the upper third and surrounded by smaller ones. In the male *bezziana* the eyes are brown, and the lenses are small and all of about the same size.

Although originally described from Guinea, I have not seen any specimens of *megacephala* from any part of Africa, so I am unable to say whether it occurs there. It is plentiful in the bazaar at Port Said, and one would expect it to occur in Egypt at least. It is, however, present in the Australian region.

There is no other Calliphorine which may be confused with *bezziana*, unless it be *Chrysomyia flaviceps*. I have not been able to identify this species with certainty, and whenever this name is used by writers in India, *Chrysomyia megacephala* is meant, so that there is some confusion regarding it; it is probably a synonym for *megacephala*.

There is much which has yet to be discovered in connection with the distribution and life-history of *Chrysomyia bezziana*. For instance, we do not know the limits of its eastern distribution. Does it occur in Malaya, the Dutch East Indies, China and Japan? I hope that those who have opportunities of collecting larvae from living tissues, either of man or animals, in any of the areas mentioned above, will do so, and send me the larvae for identification.

Cordylobia anthropophaga, Blanchard.—This is the most important specific myiasis-producing Calliphorine of Africa, where it is widely distributed, ranging from the Bahr-el-Ghazal Province of the Anglo-Egyptian Sudan in the east, and the northern limits of Senegal in the west, to Natal in the south. The most complete account of its life-history and habits will be found in Roubaud's, "Etudes sur la Faune parasitaire de l'Afrique Occidentale Française," Part 1. In its larval stage it is essentially a parasite of dogs, but is also found in a number of other domestic animals. The female fly lays her eggs in dust, sand, earth, etc., where the host is accustomed to lie. The first stage larva, which is extremely small but very active, on finding itself in the neighbourhood of the skin of a host, attaches itself to it, and then bores its way into the epidermis. It now rapidly passes through its moults, and the third stage larva, which is very distinct from the first instar in external structure, as is the case in many of the allied CALLIPHORINAE and the OESTRIDAE, forms a palpable tumour below the skin, its posterior extremity being in the vicinity of the opening into the tumour, so that air can be taken in through the posterior stigmata. These tumours never suppurate in the ordinary course of events, but may do so, if for any reason the larva dies.

Cordylobia (*Stasisia*) *rodhaini*, Ged.—This Calliphorine is the only other species whose larvae are known to cause cutaneous myiasis in Africa. It appears to be restricted to the damp forest regions of the Congo, and its larvae are normally found under the skin of the duikers, such as the bay duiker, *Cephalophus dorsalis*, and the common duiker, *Cephalophus grimmi*, as well in the large rodent, *Cricetomys gambianus*; man is only accidentally infested. Thin-skinned animals are the only ones attacked, and the immobility of the host at the time of the hatching of the larva from the egg is a necessity. As in the case of *Cordylobia anthropophaga*, the eggs are laid in damp earth, particularly where the hosts are accustomed to lie, and where urine has been voided. The first-stage larva soon makes its way into the epidermis and rapidly passes through its moults, reaching maturity in fifteen days.

A comparative study of the various larval instars with those of other CALLIPHORINAE would be of great interest, and I trust that those who have opportunities of obtaining them will send me any specimens.

Wohlfahrtia magnifica, Schiner.—This species is the only European specific myiasis-producing fly, and belongs to the family SARCOPHAGIDAE, or Flesh Flies. All the species of *Wohlfahrtia* can be distinguished from those of *Sarcophaga* by the well-defined round spots on the abdomen, instead of the shimmering chequered marks, so characteristic of all the species of *Sarcophaga*. The species of the allied genus *Sarcophila* also have round spots on the abdomen, but the arista is only plumose towards the base, while in the species of *Wohlfahrtia* the arista is plumed for some distance. *Wohlfahrtia magnifica* deposits its larvae in cuts, sores, wounds, and at the entrance to the nostrils and vagina, and on the eyelids, the fly being attracted by an offensive discharge from such tissues or organs. It is widely distributed in Southern Russia, Asia Minor and Egypt, where it is a serious pest to man and animals. Portchinsky has made an exhaustive study of its life-history and habits, as well as those of some allied species. None of the other species of *Wohlfahrtia* appear to be specific myiasis-producing flies.

Flies of the Family Oestridae.

In this family are included a large number of highly specialised flies, whose larvae can only reach maturity in certain tissues and organs of special animals and their near allies. For example, the larvae of the horse bots (*Gasterophilus*) and those of the elephant bots (*Cobboldia*) can only live in the stomachs and duodenum of the EQUIDAE and the ELEPHANTIDAE, attaching themselves deeply by their mandibular hooks to the mucous membrane of the alimentary tract. The exact nature

of the food of such larvae is not clearly understood, but from a large number of dissections and examinations of the mid-guts of the larvae of the sheep nose-bot (*Oestrus ovis*), I was unable to confirm Brauer's suggestion that these Oestrid larvae are blood-suckers. The contents of the mid-guts of larvae recently removed from their hosts clearly suggested that they had fed on serous exudations, most probably resulting from the irritation produced by the minute, but deep, punctures made by their mandibular hooks in the mucous membrane. I had several opportunities of examining the naso-pharynx of dromedaries heavily infested with the larvae of their nose-bot, *Cephalopsis titillator*, and there was no doubt whatever that the mucous membrane was in a pathological condition, and in life would exude much mucus.

The entire larval stage of the OESTRIDAE is a long one, and is chiefly passed in the third stage, but the adults, on the other hand, are short-lived. Sufficient food is taken in by the third stage larva, and stored up in the form of fat-body, so that when the adults hatch out, particularly the female, there is ample nourishment for the development of the eggs, and even for the hatching of the first stage larvae *in utero*. The adults therefore do not feed, and as a result their mouth-parts have atrophied for want of use. There can be very little doubt that when such larvae are in large numbers, the host suffers, and may, as I will point out further on, even die as a result of a massed infestation.

The OESTRIDAE are at present grouped in a number of subfamilies according to the structure of the third stage larva, and that of the adults. A few notes on the species belonging to the various subfamilies may be useful to those who have opportunities of collecting any of these flies, either as larvae or as adults. For much of the information given below I am indebted to the exhaustive works of Rodhain and Bequaert, as well as to those of Gedoelst and Roubaud.

1. Subfamily GASTEROPHILINAE.

All the species of this homogeneous group are myiasis-producers in their larval stages, the larvae living in the stomach, and in one case in the duodenum, of the horse and its allies. These larvae have occasionally been found in the stomachs of certain carnivores which had fed on dead horses, donkeys, etc., but this infestation is only accidental. In Russia some of the species now and then deposit their eggs on the hair of the human face, such as the eyebrows, and the first stage larvae then penetrate the skin, and cause the so-called "creeping myiasis," the little larva burrowing along under the skin, evidently endeavouring to find its way into the alimentary tract; they never, however, reach the stomach, and thus do not become mature. As would be expected, such larvae only belong to those species of *Gasterophilus* whose larvae normally penetrate the skin of the horse, after hatching out of the egg, and do not depend on moisture and friction to help them to leave the egg, and enter the mouth. *Gasterophilus veterinus* (*nasalis*) and *G. haemorrhoidalis* are the two species whose larvae usually cause this form of myiasis. *Gasterophilus intestinalis*, on the other hand, cannot do so, as its larvae can only hatch out of the egg with the aid of friction and moisture.

The following species of *Gasterophilus* are known in their larval and adult stages :—

Gasterophilus intestinalis, De Geer (*equi*, Clark). This is the common horse bot of Europe and North America; it has also been recorded from many parts of Africa, such as South Africa, the Belgian Congo, Senegal, French Guinea, the Gold Coast, etc. It is also found in Australia and New Zealand. In India and Mesopotamia there is a variety, *bengalensis*, Macq., which is very common in the north of India. Another variety, *asininus*, Br., is recorded from the Anglo-Egyptian Sudan, its larvae being parasitic in the stomach of the donkey.

Gasterophilus haemorrhoidalis, L.—This is also a European and North American species, and Gedoelst records it from the Belgian Congo. Its larvae are parasitic in the stomach of the horse.

Gasterophilus veterinus, Clark (*nasalis*, L.).—This species is found throughout Europe, North America, Australia, French Guinea and Mesopotamia. Its eggs are always attached to the hairs between the rami of the lower jaw, the fly darting between the legs and striking the space, each time depositing an egg. Townsend states that the eggs actually pierce the skin, but it is only necessary to examine the ovipositor to see that this is an impossibility.

Gasterophilus pecorum, F.—This is the common horse bot of Russia, Hungary and Italy ; it has also been recorded from South and West Africa. A variety, *zebrae*, Rodh. & Beq., is parasitic in its larval stage in the stomach of the zebra, *Equus böhmi*, in East Africa.

The following species are only known in their adult stages :—

Gasterophilus flavipes, Oliv.—This species is recorded from the Mediterranean region, Spain, North Africa, Asia Minor and the Anglo-Egyptian Sudan. Its larvae are believed to be parasitic in the stomach of the ass.

Gasterophilus nigricollis, Lw.—This species is only known from Bessarabia.

Gasterophilus lativentris, Brauer.—From Courland.

Gasterophilus magnicornis, Bezzi.—This species is found in the Italian Somaliland and is probably identical with *G. intestinalis* var. *bengalensis*, judging from the description. Its larvae are believed to be parasitic in the stomach of the horse and ass.

The following species are only known as larvae :—

Gasterophilus gedoelsti, Rodh. & Beq.—From East Africa ; the larvae are parasitic in the stomach of the zebra, *E. böhmi*.

Gasterophilus ternicinctus, Ged.—From Nyasaland ; the larvae are parasitic in the stomach of the zebra, *E. burchelli crawshayi*.

There are several other doubtful larvae of *Gasterophilus* that have been described. There can, I think, be very little doubt that when a critical examination is made of fresh material of the larvae and adults of the species of this subfamily, this long list of species will be reduced.

Rodhain and Bequaert place in this subfamily the bot-flies of the rhinoceros, *Gyrostigma*, of which there are three, possibly four, good species, the adults of only two being known.

Gyrostigma pavesii, Corti.—This species, the adults of which are known, is parasitic in its larval stage in the stomach of the African black rhinoceros, *R. bicornis*, which is found from Abyssinia and Somaliland, through East and Central Africa, in suitable localities down to the Cape. It is also found in the stomach of the white or Burchell's rhinoceros, *R. simus cottoni*, which is found in South and South-East Africa, as far north as the Zambesi, and again in equatorial Africa at Lado, just north of the Equator.

Gyrostigma meruenis, Sjöstedt.—The larvae of this species are parasitic in the stomach of the black rhinoceros, *R. bicornis*.

Gyrostigma conjugens, Enderlein.—The larvae of this species are also parasitic in the stomach of the same rhinoceros.

Gyrostigma sumatrensis, Brauer.—The larvae of this species were recovered from the stomach of the Sumatran rhinoceros, *R. sumatrensis*, which is found in Assam and Siam, the Malay Peninsula, Sumatra and Borneo, and also from the stomach of the Assam local race, *R. sumatrensis lasiotis*.

According to Rodhain and Bequaert the eggs of *G. pavesii* are laid on the skin of the ears, neck and shoulders of the host, so that it is very probable that the larvae are only able to leave the eggs when, as in the case of *Gasterophilus intestinalis*, they are licked ; on reaching the mouth they can then pass down into the stomach.

2. Subfamily Oestrinae.

This subfamily has recently been monographed by Rodhain and Bequaert, who recognise five genera. The larvae of *Oestrus*, *Gedoelstia* and *Kirkioestrus* are parasitic in the frontal and neighbouring sinuses of ruminants, those of *Rhinoestrus* in the same sinuses of equines, pigs and the hippopotamus ; and the larvae of *Cephalopsis* (*Cephalomyia*) in the naso-pharynx of the dromedary and camel.

The following key is taken from Rodhain and Bequaert, and may be found useful in distinguishing the genera :—

1 (*a*) Wings with a section of the apical transverse nerve (the outer section of the 4th nerve ?) turned up almost vertically to the long diameter of the wing. Long veins 2, 3 and 4 almost of the same length, ending before the last quarter of the wing. Transverse marginal vein ending before the middle of the first posterior marginal cell. Antennal pits separated on the face by a large flattened border .. .. *Cephalopsis*.

1 (*b*) Transverse apical vein not vertical to the long diameter of the wing. Transverse marginal vein ends in the middle of first posterior cell or thereabouts .. .. 2.

2 (*a*) Rudiments of proboscis elongated, prolonged in front towards the end between the palps, the extremity divided into three long cushions which represent the labella and the rudimentary lips. Antennal pits more or less confluent, but separated by a flattened round ridge. Body thick-set, covered with large papules. Abdomen short, cylindrical, almost without pilosity, Legs short and slender. Apical transverse nerve without an appendix .. .. *Rhinoestrus*.

2 (*b*) Rudiments of proboscis conical, not extending beyond the palps at the base, and without traces of labellae. Venter and posterior extremity of abdomen covered with long and fine pilosity .. .. .. 3.

3 (*a*) Antennal pits confluent, not separated by a median flattened edge. Abdomen elongated, slightly flattened dorso-ventrally, contracted and bent towards the base in front. Body without papules and gross sculpture, but with short abundant pilosity, especially on abdomen ; relatively long and robust. Apical transverse vein with an appendix .. .. *Kirkioestrus*.

3 (*b*) Abdomen squat, cylindrical, not flattened dorso-ventrally, not recurved towards the front. Body grossly sculptured, either with tufts or papules, less on thorax. Pilosity not very abundant. Short and slender legs. Apical transverse vein without an appendix .. 4.

4 (*a*) Antennal pits not confluent, separated on face by a large flattened edge. Abdomen with denticulated tufts on dorsal surface of segments 2, 3 and 4 .. .. *Gedoelstia*.

4 (*b*) Antennal pits more or less confluent, not separated by a large flattened ridge. Abdomen without any tufts on the dorsal surface. .. *Oestrus*.

The following notes on the species give the hosts in which the larvae are found :—

Oestrus ovis, L.—The common sheep and goat bot, found wherever the hosts occur. Its larvae are parasitic in the nasal passages, and are often present in large numbers. Although the larvae are easily obtained, the adults are seldom seen. The first stage larva has been recorded from man in Russia, Italy, and Algeria, in the conjunctiva, mouth and nasal cavities ; but it is more than probable that in the majority of these cases they were not those of *O. ovis* but of *Rhinoestrus purpureus*.

Oestrus variolus, Lw.—This is the common bot of the western hartebeest, *Bubalis major*, and Jackson's race of the Lelwel hartebeest ; its larvae are found in the nasal passages of a large percentage of these antelopes.

Oestrus aureo-argentatus, Rodh. & Beq.—The larvae of this species are common in the nasal passages of the roan antelope, *Hippotragus equinus*, and its local races, and in the western and Jackson's hartebeest.

Oestrus macdonaldi, Ged.—The larvae of this somewhat rare species have so far only been found in the nasal passages of Lichtenstein's hartebeest, *Bubalis lichtensteini*.

Oestrus interruptus, Ged.—The mature larva of this species is parasitic in the nasal passages of Coke's hartebeest, *Bubalis cokei*, the brindled gnu, or blue wildebeest, *Connochoetes taurinus johnstoni*, and the bastard hartebeest, *Damaliscus lunatus*.

Oestrus disjunctus, Ged.—The larva of this species is parasitic in the nasal passages of the bastard hartebeest, and the roan antelope.

Oestrus compositus, Ged.—The larva of this species is found in the nasal passages of Lichtenstein's hartebeest.

Rhinoestrus purpureus, Brauer.—This species, the larvae of which are parasitic in the nasal passages of the horse, the mule and zebra in Europe, Asia Minor, Palestine and Africa, is an important Oestrid, as the female fly has the habit of depositing its larvae in, or near, the human eye, and may thus lead to the loss of an eye. It is probably the larvae of this species that has been confused with that of *Oestrus ovis* in those cases in which the latter has been recorded from the human face.

Rhinoestrus phacochoeri, Rodh. & Beq.—The larva of this rare species is found in the nasal sinuses of the warthog, *Phacochoerus aethiopicus*, in the Belgian Congo ; the adult fly is not known.

Rhinoestrus nivarleti, Rodh. & Beq.—The larvae of this species are parasitic in the nasal sinuses of the red river-hog, *Potomochoerus porcus*, in the Belgian Congo and adjacent parts of West Africa ; the adult fly is not known.

Rhinoestrus hippopotami, Grünberg.—The larvae of this interesting Oestrid, the only species known from the hippopotamus, is parasitic in its nasal cavities.

Gedoelstia cristata, Rodh. & Beq.—The larvae of this species are found in the nasal cavities of various antelopes such as Lichtenstein's hartebeest, the western hartebeest, Jackson's variety of the Lelwel hartebeest, the white-bearded race of the blue wildebeest, and the topi or variety of the Senegal hartebeest.

Gedoelstia hässleri, Ged.—The larvae of this species are parasitic in the nose and accessory sinuses of Lichtenstein's hartebeest and the bastard hartebeest.

Kirkioestrus surcoufi, Ged.—The larvae are parasitic in the nasal cavities of the western hartebeest, Jackson's hartebeest, and species of the lechwe in various parts of West Africa.

Kirkioestrus blanchardi, Ged.—Its larvae are parasitic in the nasal cavities of Lichtenstein's hartebeest in the basin of the Zambesi.

Kirkioestrus minutus, Rodh. & Beq.—The larvae of this species are parasitic in the nasal cavities of Jackson's hartebeest and the topi, in the Congo.

Cephalopsis titillator, Clark (*Cephalomyia maculata*, Macq.).—The larvae of this species, the only bot-fly of the CAMELIDAE, is parasitic in the naso-pharynx of the dromedary and the camel, wherever these animals are found.

3. Subfamily COBBOLDIINAE.

The stomach-bots of the Indian and African elephants are placed in this subfamily, and there seems little doubt that they are near allies of the equine stomach-bots, the GASTEROPHILINAE.

Cobboldia elephantis, Steel.—The larvae of this species are parasitic in the stomach of the Indian elephant. I have been told by those who have to do with the elephants kept by the Government of Madras, in various parts of South India, that this bot-fly is a serious pest. There seems little doubt that when the larvae are in large numbers in the stomachs of the elephants, especially the young animals, they suffer in health, often being on the sick list with digestive troubles, and are unable to work; and in bad infestations the young animals may even die. Mr. Chari, Veterinary Inspector, Mount Stuart, sent me a large number of third stage larvae of *C. elephantis* that were collected from the stomach of a calf elephant, which was so full of larvae that there was hardly any room for a pin to pass into it. The eggs are laid at the root of the tusk or trunk, and the larvae only hatch out when the eggs are moistened. I had a large number of these eggs collected about a month after they were laid, and as soon as they were placed in some water the young larvae immediately burst open the eggs and emerged; they are very active and can crawl considerable distances.

The African elephant is parasitised by the larvae of three species of *Cobboldia*. The larvae of *Cobboldia loxodontis*, Brauer, have been recorded from Uganda, the Belgian Congo, and the Ivory Coast, but its distribution is probably much wider; those of *C. chrysidiformis*, Rodh. & Beq., have so far only been found in the stomachs of elephants from the Belgian Congo; while those of *C. parumspinosa*, Ged., have been recorded only from the basin of the Zambesi.

4. Subfamily Hypodermatinae.

This subfamily contains all those Oestridae whose larvae cause cutaneous myiasis in ruminants, chiefly cattle and antelopes. The following are the more important species:—

Hypoderma bovis, De Geer.—The larvae cause the well known warbles, which are common in the hides of cattle in Europe and North America. Captain Cross, C.V.D., has sent me what appear to be the larvae of this species from the skins of goats in the Punjab, a very large percentage of the animals being infested.

Hypoderma lineata, de Villers.—The larvae are also parasitic in the hides of cattle in Europe and North America, but are not so common as those of *H. bovis*. It is only recently that the method of infestation has been worked out in the case of *Hypoderma bovis* by Carpenter in Ireland, Gläser in Germany, and Hadwen in Canada. The females of these two species lay their eggs on the hairs of the legs of cattle, and the larvae on hatching out penetrate the skin adjacent to the hair, and then slowly migrate upwards until they reach the submucous coat of the oesophagus, resting there for some time in the second larval stage. Later they pass along the muscles of the back and eventually reach the back and sides of the animal, where they make a small opening in the skin. When mature they leave the skin and pupate in the ground.

Hypoderma diana, Brauer, and *H. actaeon*, Brauer.—The larvae of these two species are parasitic in the skins of the red deer in Germany and Britain.

Hypoderma silenus, Brauer, is parasitic in its larval stage in the skin of the ass in Egypt: *Hypoderma desertorum*, Brauer, is also found in Egypt, but its host is not known. *Hypoderma gazellae*, Ged., is parasitic in its larval stage in the skin of Grant's gazelle in East Africa. *Hypoderma corinnae*, Crivelli, in the skin of the Dorcas gazelle, *Gazella dorcas*.

Oedemagena.—This genus, which contains only one species, differs from *Hypoderma* in having small oval labella, which are absent in *Hypoderma*. *Oedemagena tarandi*, L., is parasitic in the hides of reindeer in Lapland and Norway.

5. Subfamily Cuterebrinae.

In this subfamily are placed a somewhat heterogeneous collection of genera and species, all the larvae of which are parasitic in the skin and subcutaneous tissues of small rodents, chiefly Muridae; they are only found in North and South America. Townsend raises the subfamily to a family, the Cuterebridae, and gives the following key to the genera:—

(1) No facial carina; antennal pit large and deep; antennae elongate .. 2.
Facial carina present; antennal pit small and shallow; antennae short 3.

(2) Epistoma rather broad, projected obliquely forward and downward between the peristomalia; arista thickly long-plumose to tip *Pseudogametes.*
Epistoma very narrow, projected straight downward between the peristomalia; arista with hairs on upper side only .. *Dermatobia.*

(3) Arista nude .. .. *Rogenhofera.*
Arista with hairs on upper side and on apical part of lower side .. 4.

(4) Antennal pit extended below in a tapering prolongation, the peristomalia converging obliquely and meeting near the lower end of carina .. .. *Cuterebra.*
Antennal pit circumscribed below, subcircular, the peristomalia parallel and closely approximated to the carina for about the lower half of its length .. .. *Bogeria.*

The following are the more important species:—

Pseudogametes hermanni, Br., and *P. semiatra*, Wied., from the subcutaneous tissues of Muridae in Brazil.

Dermatobia hominis, L.—The larvae of this species are chiefly found in the skin of cattle in tropical America and the neighbouring islands; man is seldom parasitised. It is now known that the female fly lays its eggs in small batches on the bodies of blood-sucking and sweat-loving insects, such as the Culicid, *Janthinosoma lutzi*, and species of *Anthomyia*, and the larvae hatch out when the egg-carrier visits the vertebrate host to feed, penetrating the skin and forming a local tumour.

Rogenhofera grandis, Guérin, *R. trigonocephala*, Br., and *R. dasypoda*, Br., from the skins of Muridae in Argentine and Brazil. *Cuterebra americana*, F., *C. cuniculi*, Clark, *C. analis*, Macq., *C. approximata*, Walk., *C. histrio*, Coq., *C. tenebrosa*, Coq., *C. atrox*, Clark, and *C. maculosa*, Knab, all from the skins of small rodents in North and Central America.

Cuterebra ephippium, Latr., larvae parasitic in the skins of Muridae in French Guiana, *C. patagona*, Guér., from Patagonia, *C. megastoma*, Br., from South America, *C. funebris* from Trinidad, *C. apicalis*, Macq., *C. cayennensis*, Macq., *C. rufiventris*, Macq., *C. nigrocincta*, Aust., *C. sarcophagoides*, Lutz, *C. nigricans*, Lutz, *C. infulata*, Lutz, and *C. schmalzi*, Lutz, from Brazil. *Bogeria emasculator*, Fitch, *B. grisea*, Coq., *B. buccata*, F., *B. fontenella*, Clark, *B. princeps*, Aust., *B. fasciata*, Swenk., *B. scudderi*, Towns., all from North and Central America.

From the studies of Hadwen, and Parker and Wells, it seems that these Cuterebrine bot-flies deposit their eggs on the hairs of their hosts, and that they are then licked off and enter the alimentary tract, later migrating outwards to the skin, where they cause dermal myiasis.

6. Subfamily Cephenomyinae.

In this subfamily are included a small number of Oestrids, the larvae of which are parasitic in the nose and accessory sinuses of the Cervidae and Bovidae and one species in the oesophagus of the African elephant. Most of the species are found in

Europe and in North and South America. As in the case of the OESTRINAE, the females are viviparous and deposit their larvae at the entrances of the nostrils, the larvae then migrating up into the frontal sinuses, and down, even into the oesophagus.

Cephenomyia auribarbis, Mg., is a common parasite in its larval stage in the red deer in Europe; the larvae of *C. ulrichi*, Br., in the elk; *C. trompe*, L., in the reindeer; *C. stimulator*, Clark, in the roe; and *C. abdominalis*, Aldrich, from the Adirondacks, New York. *C. pratti* is parasitic in its larval stage in the American elk, the mule deer, and several other deer in North America. *C. phobifer* is only known in its adult stage from North America, and *C. macrotis* has been recorded in its larval stage from the mule deer in North America.

Semi-specific Myiasis-producing Diptera.

In this group I include all those flies which, though normally breeding in the bodies of dead animals, and even in vegetable matter, will occasionally lay their eggs, or deposit their larvae, in the diseased tissues of man and animals. The female fly is in each case attracted by a foul discharge from a sore, wound or diseased organ, such as the nose or ear, or even in soiled wool. The following species belong to this group:—

Calliphora erythrocephala, Mg.
,, *vomitoria*, L.
,, *quadrimaculata*, Swed.
,, (*Anastellorrhina*) *augur*, L.
Cochliomyia (*Chrysomyia*) *macellaria*, L.
,, *viridula*, R.D.
Chrysomyia megacephala, F. (*dux*, Esch.).
,, *marginale*, Wied.
,, *albiceps*, Wied. (*rufifacies*, Guérin).
,, *varipes*, Macq.
Pollenia stygia, F.
Phormia regina, Mg.
Cynomyia cadaverina, R.D.
Lucilia sericata, Mg.
,, *caesar*, L.
,, *argyricephala*, F. (*serenissima*, Macq.).
,, *tasmaniensis*.
Sarcophaga ruficornis, F.
,, *chrysostoma*, Wied.
,, *plinthopyga*, Wied.
Aphiochaeta xanthina, Speiser.
,, *rufipes*, Mg.

A few notes on the above species may be useful.

Calliphora.—All the species belonging to this genus of blowflies are large robust insects of a dark blue colour, often with lighter patches on the abdomen. The palpi are nearly always reddish, the legs black, and the thorax adorned with large bristles. The females, which are oviparous, occasionally lay their eggs in living tissues of man and animals, though normally ovipositing in decaying animal matter; the habit of ovipositing in diseased tissues is not well established in the species of this genus.

Cochliomyia.—These blowflies can be distinguished at once from their Old World allies of the genus *Chrysomyia* (*Pycnosoma*) by the well-marked dark dorsal thoracic stripes. *C. macellaria*, the notorious screw-worm fly of tropical America, like its ally, *Chrysomyia bezziana*, will lay its eggs in any diseased tissues, but unlike it, will also breed freely in the bodies of dead animals, and even in decaying vegetable matter. Its control is therefore a much more hopeless task than that of *Chrysomyia*

bezziana. The larvae of *Cochliomyia viridula* are known to cause cutaneous myiasis in man and animals in British Guiana and Trinidad. Doubtless there are several other species of this genus in South America with like habits.

Chrysomyia (*Compsomyia, Pycnosoma*).—The blowflies of this genus are usually of a bluish green colour, and have well-marked horizontal bands on the hind borders of the abdominal segments. The thoracic bristles are reduced, the dorsal surface being covered instead with fine hairs. *Chrysomyia megacephala* is one of the species that occasionally deposits its eggs in the tissue of animals in India. It is very similar in general appearance to *Chrysomyia bezziana*, as pointed out above. *Chrysomyia marginale* is a common African species, and though mainly breeding in decomposing bodies of animals and birds, will occasionally lay its eggs in, or near, diseased tissues. *Chrysomyia albiceps* (*rufifacies*) is, according to Froggatt, a notorious sheep maggot fly in Australia, its larvae being found in company with those of two other blowflies, *Anastellorrhina augur* and *Pollenia stygia*. In India I have noted that the larvae of *albiceps* are entirely predaceous, feeding on the larvae of other CALLIPHORINAE, so that it seems possible that it lays its eggs in soiled wool in Australia, being attracted by the presence of other larvae ; this point requires further investigation. *Chrysomyia varipes* is a smaller species with a somewhat similar larva ; it also breeds in soiled sheep wool in Australia.

Anastellorrhina augur is a well-known sheep maggot fly in Australia. It is a large species, suggesting affinities with *Calliphora*. The larva, as I will point out further on, is very similar in structure to that of *Calliphora erythrocephala*.

Pollenia stygia (*villosa*) is another allied species, which is placed in this genus because of the fine yellow hairs on the sides of the thorax. It is a serious pest to farmers in Australia.

Phormia regina, though a common fly in Europe, is not, so far as I am aware, known to cause myiasis in animals. In America, however, it often lays its eggs in soiled wool and in wounds of sheep, particularly old suppurating wounds. Bishopp states that its larvae are often found in sheep with broken horns.

Cynomyia cadaverina very occasionally causes myiasis, more especially in very foul wounds on animals. It is, however, a regular breeder in decaying animal matter.

Lucilia.—The species of this genus of bright metallic green blowflies can be distinguished from the species of the genus *Chrysomyia* by noting that there are many strong bristles on the thorax, arranged in two parallel rows. *Lucilia sericata* is the most notorious species, for it regularly lays its eggs in the soiled wool and tissues of sheep in Europe, and more particularly in Scotland. It is also recorded from Australia as a sheep-maggot fly. *Lucilia caesar* only very occasionally lays its eggs in living tissues. *Lucilia argyricephala* is the common Oriental species and occasionally lays its eggs in the diseased tissues of animals. *Lucilia tasmaniensis* is said to be a myiasis-producing species in Tasmania.

Sarcophaga.—All the species of this cosmopolitan genus are very characteristic large grey flies with red eyes. Though easily recognizable generically the species are exceedingly difficult to determine. All are semi-specific myiasis-producing flies normally breeding in dead bodies and decomposing animal matter. In India there is, at least, one species which deposits its larvae in wounds, particularly those exuding very foul pus, and the larvae, owing to their large size, cause very extensive destruction, so that there can be no mistaking a case of myiasis caused by such larvae. This species is believed to be *ruficornis*, but this identification is not certain. I would particularly urge all those who have opportunities of collecting the larvae of species of *Sarcophaga* from cases of myiasis to breed out the flies, for it is only by doing this that we can be certain of the species and can then study its habits and distribution. *Sarcophaga lambens*, Wied., and *Sarcophaga pyophila*, Neiva, are recorded as causing myiasis in Central and South America. *Sarcophaga chrysostoma*, Wied., in British Guiana, and *S. plinthopyga*, Wied., are also notorious myiasis-producing species.

Aphiochaeta.—The species of this Phorid genus can be recognised by their peculiar habit of moving in a jerky manner, and by the structure of the antennae and the characteristic venation. *A. xanthina* (*ferruginea*) is a yellowish brown species, which is widely distributed in the tropics, and its larvae cause cutaneous myiasis in man and animals. *A. rufipes* is also a myiasis-producing species, but not so common as *xanthina*.

Accidental Myiasis-producing Flies.

In this group are included an assemblage of unrelated Diptera—the larvae of which occasionally find their way into the intestinal tract of man. They normally breed outside the human body in organic and vegetable matter, some of which is used as human food, and people who are not particular with regard to what they eat become infested. It should be clearly understood, however, that these flies do not intentionally deposit their eggs or larvae in certain human foods in order that their larvae may reach the intestinal tract ; the food is merely their usual breeding ground. Although many of the OESTRIDAE live in their larval stages in the intestines of animals, they are not accidental myiasis-producing flies, the intestinal tract is the only place in which their larvae can reach maturity.

So far as I can gather, intestinal myiasis is an uncommon condition, even in countries like India, for in spite of the fact that I specially drew attention to it in the circular mentioned above, which was sent to every medical and veterinary officer, and in spite of the fact that some medical men have told me that it is very common in parts of the country, I received such larvae from only two cases.

The well known " rat-tailed " larvae of *Eristalis tenax* and *Helophilus pendulus*, which normally live in foul ditch water, may be acquired by those, particularly children, who drink such water, when they are likely to swallow large numbers of small larvae of these drone-flies. In the same way, vegetables, such as lettuces and mustard and cress, grown under insanitary conditions and eaten without being washed, may contain eggs and larvae of *Eristalis tenax* and allied species. The eggs and larvae of *Fannia* and *Anthomyia* may also be swallowed intact in uncooked vegetables, especially raw carrots. Onion fly larvae may be swallowed when eating diseased spring onions, and species of *Drosophila* in over-ripe fruit, such as bananas and oranges. *Sarcophaga* larvae are sometimes swallowed in imperfectly cooked meat, particularly cold meat, and game that is commencing to decompose. In the case of *Aphiochaeta xanthina* (*ferruginea*), the larvae of this small Phorid are most probably swallowed in meats of all kinds, especially when beginning to decompose, as this substance is a favourite breeding ground for the fly. One remarkable case has been published in which the larvae, puparia and adults of this fly were passed in the faeces of a patient for a considerable time, suggesting that the larvae were able to reach maturity in the intestine, and the puparia remain alive, so that the adults could hatch out. Recently in Coonoor, I attempted to infect monkeys by feeding them on large numbers of eggs and larvae of this species, but although a most careful search was made for any stages in their excreta, I was never able to recover either larvae, puparia or adults. It would be worth while repeating this experiment, using only one monkey and making a more thorough search than I was able to undertake. Such small larvae as those of *Aphiochaeta* easily escape detection when the tray under such a monkey contains a considerable quantity of remains of food in addition to its faeces.

So far as I am aware, the larvae of the CALLIPHORINAE are unable to live in the intestine of man and animals, but in order to set aside any doubt on the subject I fed a dog with large numbers of eggs and larvae of some common Indian species, but not a single living larva was passed out, and it would appear that such larvae, when swallowed, soon die. But during the course of my enquiry into the myiasis-producing flies of India, two masses of eggs of *Chrysomyia megacephala* were sent me as having been passed out in the faeces of a patient. The eggs were intact, and

the medical officer was emphatic in his statement that they were actually passed out, and had not just been deposited on the faeces. In any case, *Chrysomyia megacephala* certainly does not breed in human excrement, so far as I know. It would be worth while carrying out some more experiments in this direction to see whether the eggs of CALLIPHORINAE can hatch out in the intestine, and the larvae reach maturity and be passed out in a living condition.

Lastly, it is necessary to refer to the larvae of *Fannia canicularis* from the urinary tract. There is at present no satisfactory explanation as to how such larvae can reach the human bladder. The usual explanation that they pass down the urethra when very small, seems to me to be highly improbable, at least in the case of the male urethra, for it will be remembered that the larva of *Fannia*, even when small, is not entirely smooth, and would cause very considerable irritation. The presence of such larvae in this organ is at present a mystery, and the subject requires to be re-investigated.

Identification of the Larvae of Myiasis-producing Diptera.

It will be remembered that the larvae of the higher Diptera are soft cylindrical maggots, usually of a greyish white to yellowish white colour. The head end is pointed and the body gradually increases in diameter backwards, the posterior end being truncated, with a concave surface looking upwards and backwards. Such a larva is divided into segments, the number of which is at present a matter of dispute, and it is not possible to homologise them with those of the adult. The head contains a characteristic skeleton consisting of a number of sclerites, spoken of as the cephalopharynx. The mouth is armed with a pair of mandibular hooks, and the anterior spiracles open at the sides of the apparent third segment. The posterior stigmata are placed on the concave surface of the apparent eighth abdominal segment. Banks, MacGregor and Metcalf have drawn attention to the value of the posterior stigmata in determining the larvae of the higher Diptera. Metcalf in particular says that, "So superior are the characteristics drawn from this part of the larva, that I regard most descriptions which omit consideration of them as practically worthless. For in most cases the general features of shape, colour, etc., may be found to apply almost equally well to other species. The most available, absolutely diagnostic characters are to be found on the posterior stigmata." In my own studies of the larvae of Diptera I have found that the characters of the posterior stigmata, cephalopharynx and anterior spiracles, taken together, afford the best and only reliable means of accurately determining the larva of any species of Diptera, and more particularly of those of the higher Diptera. In making a preparation of the posterior stigmata of a Muscid larva for purposes of identification, I always make it a rule to include the cephalopharynx and anterior spiracles as well. I will now shortly describe these structures in the various types of larvae of the myiasis-producing Diptera, and point out how their characters can be utilised in determining any particular larva.

Posterior stigmata. In the third-stage larvae of all the higher Diptera the posterior stigmata consist of a pair of chitinous plates, which, when cleared in caustic potash, are seen to be surrounded by a ring of chitin, usually spoken of as the peritreme. Situated within this ring there are three or more openings which lead into the tracheae. Each opening is guarded by a number of delicate chitinous rods, giving the appearance of a grating; these rods form a network across the inner side of the openings. Plate 5, fig. 1, represents a vertical section through one of the stigmatic plates of the third-stage larva of *Pollenia stygia*. The deeply shaded portions represent the chitinous parts of the plate, and the lighter-shaded parts the epidermis. The three slits open into a large cavity, to the margins of which the trachea is attached; Lowne termed this cavity the vestibule. Just inside each slit there is a series of branched yellow chitinous rods, known as the grating, and lining the whole cavity a delicate network of epidermal fibres. The grating is evidently of use in preventing

the entry of foreign particles into the vestibule, and the epidermal fibrous network probably aids in retaining the air in the vestibule. The tracheae are lined externally by characteristic peritracheal cells. Situated on the inner and lower side of each plate, and usually within the chitinous ring, there is a small raised area, spoken of by Banks as the " button." In a vertical section through this structure it will be noted that it is a fine channel into the vestibule and is lined by a layer of peritracheal cells; so far as I can ascertain, it is an accessory opening, but I am unable to say at present whether it is functional or not. It is certainly not a point of attachment for muscles, as it is within the vestibule. This short description will enable the reader to understand this wonderful bit of apparatus. All the types which I have sectioned are of similar structure, no matter whether the tracheal slits be straight, as in the CALLIPHORINAE, curled as in *Musca*, or multiple as in *Oestrus* and allied genera, so that I can see little use in splitting them up into various types according to the shape of the slits. The important point to be ascertained is whether the straight or the curled slit is the more primitive, and this can only be ascertained by a comparative study of the stigmatic openings of a large number of the first stage larvae of the higher Diptera. An oval opening, such as is present on the anterior spiracles of most Dipterous larvae, seems to be the most primitive type, and from such an opening the various slits seen to-day in the posterior stigmata of the higher Diptera may have originated, but this is at present mere conjecture.

Turning now to the various kinds of slits, leading into the tracheal vestibule of the posterior stigmatic openings, we note the following types :—(1) Curled slits, (2) straight slits, and (3) round or oval openings.

1. *Curled slits.* This type of opening is characteristic of the larva of *Musca* and allied genera, the three openings occupying an excentric position on the plate, and the ends of the upper and lower appearing to coalesce with those of the middle slit. The button area is well within the chitinous ring, which, in this case, is often D-shaped and broad. In Plate v, figs. 2, 3, 4 and 5, are illustrated the posterior stigmata of *Musca domestica, Musca nebulo, Musca humilis* and *Philaematomyia crassirostris*, and without going into details it will be seen that, though very closely similar to each other, it is possible to note small distinctions sufficient for determining the species. But I would like to point out that the determination is considerably facilitated by comparing the structure of the cephalopharynx and anterior spiracles of each species at the same time. Recently I was able to determine the larva of *Musca* (*Philaematomyia*) *crassirostris* sent me from a case of intestinal myiasis by comparing the posterior stigmata with those of Indian species of *Musca*. Curled slits are also seen in the posterior stigmata of the larvae of the GASTEROPHILINAE, especially in the larvae of the species of *Gyrostigma*. Here, however, the grating is simpler than in the larvae of *Musca*.

2. *Straight slits.* This type of slit is characteristic of the opening of the posterior stigmata of the larvae of the CALLIPHORINAE, SARCOPHAGIDAE and some OESTRIDAE, such as the larvae of *Cobboldia*. In the larvae of the CALLIPHORINAE the posterior stigmata are of two kinds, one typically seen in the larvae of *Calliphora* and *Lucilia*, in which there is no break in the chitinous ring and the button is enclosed by it ; the other in *Chrysomyia* and *Cochliomyia*, in which the ring of chitin is so thin on the inner and lower angle of the plate as to give the appearance of a break, the button lying in what is but a thin layer of chitin. This type is illustrated in Plate vi, figs. 9, 10 and 11, which represent the posterior stigmata of *Calliphora erythrocephala, Lucilia sericata* and *Lucilia argyricephala*, all drawn to the same scale. Further, it should be noted that in each of these there are characteristic breaks in the chitin, between and close to the slits, appearing as round or oval spaces ; these clear spaces are extremely constant in the same larva. This close similarity between the posterior stigmata of *Calliphora* and *Lucilia* makes it difficult to separate the larvae of *Calliphora erythrocephala* from those of *Lucilia sericata*. Veterinary officers may find

this so, when they have to determine a larva taken from a sheep in this country. A careful examination of the plates when cleared in caustic potash and mounted on a slide will, however, help to separate the species. In the larva of *Calliphora erythrocephala*, as well as in that of *C. vomitoria*, the plates are distinctly larger and further apart than those of the larva of *Lucilia sericata*. In addition, in *Calliphora* there are two processes of the rim which project in between the upper and middle slit, and the middle and lower slit, whereas in *Lucilia sericata* there is only one projection between the middle and lower slit. These points, together with certain differences between the cephalopharyngeal skeletons and anterior spiracles of the two species, will make identification easy, but it is necessary to point out that mere examination of the larvae with a hand lens is not sufficient. Plate vi, fig. 13, illustrates the posterior stigmata of the third-stage larva of *Anastellorrhina augur*, and it will be noted that they are very similar to those of *Calliphora*. This alone, in my opinion, indicates the affinity of this blow-fly. The larva of *Cynomyia cadaverina* also has posterior stigmata of this type, as is seen in fig. 9 ; here, however, the clear spaces are not seen. The posterior stigmata of *Lucilia argyricephala* are smaller than those of *L. sericata* and more widely separated.

In the larvae of *Chrysomyia* and *Cochliomyia* the posterior stigmata appear to have a break in the chitinous ring on the lower and inner face, the plates are, as a whole, larger, and the button area is situated at the lower angle. Plate vi, figs. 14, 15, 16 and 17, illustrate the posterior stigmata of the larvae of *Chrysomyia megacephala*, *Chrysomyia bezziana*, *Cochliomyia macellaria* and *Phormia regina*, which also belongs to this group. It is interesting to note that in the case of the two myiasis-producing species, *macellaria* and *bezziana*, the slits are short and wide, those of *bezziana* having characteristic clear spaces between and near the slits ; these two flies are evidently very closely related.

Apart from other differences, such as the shape of the truncated posterior end, the larvae of the SARCOPHAGIDAE can always be distinguished from those of any of the CALLIPHORINAE by noting that the posterior stigmata are situated in a deep cleft, and that the internal slit slopes downwards and outwards, the middle almost straight down, and the outer slit a little inwards and backwards. The plates are always large and the slits long and somewhat narrow, and there is a characteristic break in the chitinous ring at the inner and lower angle ; the posterior stigmata of the third stage larvae of a species of *Sarcophaga* taken from a case of cutaneous myiasis in India are shown in Plate vi, fig. 18. The cephalopharynx and anterior spiracles of the larva of *Sarcophaga* are also very distinct, as I will point out further on, so that there should never be any difficulty in identifying a larva of this family of flesh-flies.

The posterior stigmata of the larvae of the elephant bots are very characteristic. The plates have here coalesced and the chitinous ring is feebly developed, the margins of the ring being probably represented by an island of chitin on the inner face. The slits are long and almost straight, situated close to one another; fig. 6, Plate v, illustrates the posterior spiracles of the third-stage larva of *Cobboldia elephantis* from the Indian elephant. The button area has apparently disappeared in this type of posterior stigmata. On larval structure alone, then, *Cobboldia* suggests affinities with a Calliphorine on the one hand and a *Sarcophaga* on the other.

3. *Single round or oval openings.* This type of posterior stigmata is well seen in the third-stage larva of the sheep nose-bot, *Oestrus ovis*. The plates are large, somewhat kidney-shaped, and the whole surface is dotted with minute openings of varying shapes and sizes. The button area is well marked and almost central in position. A similar plate is seen on the larva of the camel bot, *Cephalopsis titillator*, Plate v, fig. 7; the button area here is situated about the middle of the inner face of the plate, and is somewhat difficult to see. The posterior stigmata of the larva of *Hypoderma* (Plate v, fig. 8) also belong to this type, the openings here being arranged in more

or less regular rows, with strong bars of chitin projecting in between them. This type of posterior stigmata would, at first sight, appear to be extremely complicated, but I am inclined to think that they merely represent a breaking up of the original long slit into smaller ones to allow of a larger amount of air being taken in. The origin of this type can, however, only be determined by a comparative study of the first-stage larvae of a number of different species.

Cephalopharynx. This structure in the third-stage larva of the higher Diptera consists of a number of paired sclerites, some of which have fused, articulating with each other to form a strong chitinous skeleton. At the anterior end there is a pair of

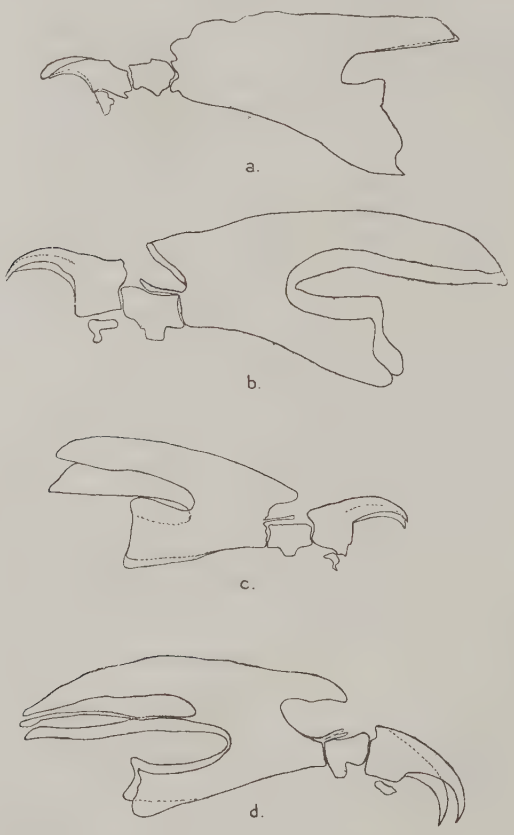

Fig. 1.—Cephalopharyngeal skeletons of third-stage larvae of: (*a*) *Musca nebulo*; (*b*) *Calliphora erythrocephala*; (*c*) *Lucilia sericata*; (*d*) *Sarcophaga* sp.

mandibular sclerites or hooks, each with a broad base, which project between the oral lobes and are used by the larva to attach itself to any object, and also in progression. Articulating with the ventral surface of the base of each hook there is a small, irregular sclerite, which Hewitt speaks of as the dental sclerite. Posteriorly the base of each mandible articulates with an irregularly shaped sclerite, which consists of two parts fused ventrally. These, again, articulate with small processes on the anterior end of the large pharyngeal sclerite, which at once suggests the fulcrum of the adult fly, and is shaped like the old-fashioned Spanish stirrup-iron.

The shape of the mandibular sclerites and the fulcrum (pharyngeal sclerite) is very characteristic in the third stage larvae of the different genera of the higher Diptera. In fig. 1 (*a–d*) the cephalopharyngeal skeletons of the third-stage larvae of *Musca nebulo*, *Calliphora erythrocephala*, *Lucilia sericata* and *Sarcophaga* are illustrated, all being drawn to the same scale. The differences are obvious, and therefore I do not intend here giving a detailed description of them. It is, however, necessary to point out that in the case of the larvae of *C. erythrocephala* and *Lucilia sericata* the differences are small, but nevertheless sufficient to determine the species. I will on another occasion deal at length with the structure of the cephalopharyngeal skeletons of a number of the larvae of the higher Diptera. I would, however, like to point out that in the larva of *Musca* and allied genera there are always two mandibular hooks, and not one, as is usually stated in the books and papers on the subject. This error is no doubt due to the fact that the left hook is shorter and narrower than the right, and is therefore easily overlooked. It is a valuable diagnostic character in this group.

Anterior spiracles. The anterior spiracular openings are always situated at the sides of the lower border of the apparent third segment. Each consists of a fan-shaped

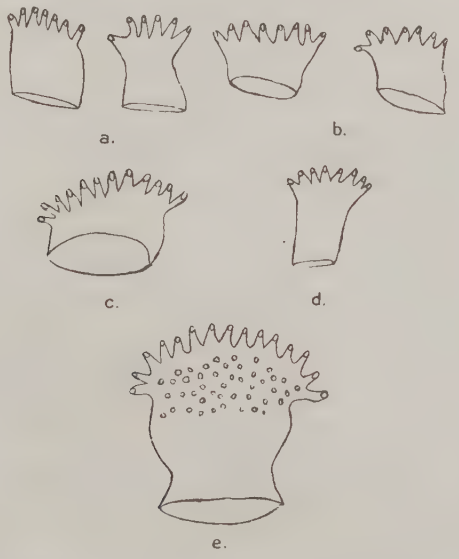

Fig. 2.—Anterior spiracles of third-stage larvae of: (*a*) *Musca domestica*; (*b*) *M. nebulo*; (*c*) *Calliphora erythrocephala*; (*d*) *Lucilia sericata*; (*e*) *Sarcophaga* sp.

chitinous structure with a varying number of small finger-like processes at the apices of which there are oval openings. These openings lead into a miniature vestibule, which is continuous with a large trachea; in the majority of the third-stage larvae the anterior spiracles are functional. They are always absent in the first-stage larva, and appear only in the second instar. Although there is great variation in the number of the finger-like projections in the same species, and even in the same larva, these structures are very useful for diagnostic purposes when taken along with the characters of the posterior stigmata and the cephalopharyngeal skeleton. In the third-stage larva of *Musca domestica* (fig. 2, *a*) there may be five, six, or seven processes; in *M. nebulo* (fig. 2, *b*) seven or eight; in *Calliphora erythrocephala* (fig. 2, *c*) eleven or

twelve; in *Lucilia sericata* (fig. 2, *d*) seven or eight. In *Sarcophaga* (fig. 2, *e*) the anterior spiracle is large, and there may be sixteen or more processes, and the vestibule has many small, clear circular areas.

I have, I think, now shown that if the characters of the posterior stigmata, cephalopharyngeal skeleton and anterior spiracles are taken together, the species to which any given larva belongs can be determined with certainty.

The following key to the larvae of some of the more important myiasis-producing Diptera (exclusive of the OESTRIDAE) will be useful for reference.

Key for Identification of some of the Larvae of the Myiasis-producing Diptera.

1. Larvae with fleshy processes; posterior spiracles at the end of tubercles or a tube.

(*a*) Small broad, dirty white larvae about 4 mm. in length, with small pointed fleshy processes in pairs on dorsum, increasing in length from before backwards; two long fleshy processes at sides of last segment, which is the broadest; posterior stigmata on brown chitinous tubercles, each with a narrow opening; movements caterpillar-like *Aphiochaeta xanthina* (*ferruginea*).

(*b*) Similar larvae, with hairy processes. .. .. *A. rufipes*.

(*c*) Medium-sized to large larvae with long pointed fleshy processes dorsally and laterally, increasing in length from before backwards, with small spines at their bases, shaft and ends bare; body compressed dorso-ventrally; posterior stigmata stalked, consisting of four lobes, each with an opening situated on dorsum of sides of apparent 8th segment .. .. *Fannia canicularis*,

(*d*) Fleshy processes with numerous branches, giving the process a feathery appearance .. .. *Fannia scalaris*.

(*e*) Medium-sized to large larvae with long pointed fleshy processes with a small tuft of spines at their apices; posterior stigmata in cleft at end of apparent 8th abdominal segment, consisting of large chitinous plates with broad rims, and three straight slits directed downwards and inwards *Chrysomyia albiceps* (*rufifacies*), *C. varipes*.

(*f*) Large soft larvae; integument covered with hairs and spines; seven pairs of short pseudopods on ventral surface; posterior stigmata situated at the end of a long tube, which can be telescoped or extended at will *Eristalis*, *Helophilus*.

1′. Medium-sized to large smooth larvae without any fleshy processes; posterior stigmata normal, not at the end of tubercles or a tube .. .. .. 2.

2. Posterior stigmata somewhat D-shaped; button area situated well within the ring; slits curled.

(*a*) All slits with three convex loops outwards .. *Musca domestica* and allies.

(*b*) Upper and lower slits with two loops, convex externally; middle slit with only one .. .. *Philaematomyia*.

2′. Posterior stigmata large, rounded or oval, with straight slits .. .. 3.

3. Chitinous ring complete and inclosing button area. *Calliphora*, *Lucilia*, *Cynomyia*. (For distinctions see drawings of posterior stigmata.)

3′. Chitinous ring incomplete .. .. 4.

4. Slits all directed downwards and inwards. *Chrysomyia*, *Cochliomyia*, *Phormia*. (For distinctions see drawings of posterior stigmata.)

4′. Internal slits comma-shaped, directed downwards and outwards; middle slits almost straight down; outer slits directed downwards and inwards *Sarcophaga*.

I will now suppose a medical or veterinary officer has a case of myiasis, and wishes to know how best to set about rearing the larvae, breeding out the flies and identifying at least the genus to which the larva belongs. If the case is one of dermal or subdermal myiasis, for instance a cut, sore or wound on the human body or that of an animal, there should be no difficulty in obtaining a number of living larvae. It is sometimes quite easy to extract the larvae without injuring them, but in the case of *Chrysomyia bezziana* the strongly developed, backwardly directed spines catch in the tissues, and, as often as not, the larva is torn in half, and then is only of use for purposes of identification. It is best to apply a small quantity of glycerine or very dilute chloroform water to the area where the larvae are, and then some will emerge, or so alter their positions that they can be extracted without damage. It is very probable that the larvae are all at the same stage, though there may be more than one species present. As many as can be removed alive should be placed in a tube, and one or more then dropped into boiling water in order to stretch them out and render examination more easy. The truncated end should be examined with a hand lens, and if the posterior stigmata are small and there are only two slits the larva is a second-stage one. A few should now be preserved in 80 per cent. alcohol, after killing them by dropping them into boiling water or hot 70 per cent. alcohol, and a label with details written in pencil put in the tube, which should be well corked. It is now necessary to rear the remaining living larvae, and this is best accomplished by placing them on a piece of meat, or in the mouth of a dead bird or small animal. Those who have not reared any of the larvae of the myiasis-producing Diptera may be misled by thinking that this part of the investigation is quite easy, but I would like to warn them that this is by no means the case; indeed it is by far the most difficult part of such an inquiry. In the Tropics great care has to be taken to prevent other blowflies, and particularly species of *Sarcophaga*, from laying their eggs or depositing their larvae, as the case may be, in the meat or the body as soon as it begins to decompose. I have tried every kind of receptacle in which the meat, etc., was placed, and have even sealed the lid with vaseline, but in every case the larvae of other blowflies, and especially *Sarcophaga*, have made their way in, and then the special larvae removed from the case of myiasis have soon disappeared. Fabre long ago suggested that a paper bag was the best way to prevent blowflies from laying their eggs in meat; and taking advantage of this suggestion I placed the meat containing the larvae to be reared in several sheets of newspaper, turning down the ends and tying it up into a packet. No larvae can now find their way into the packet, provided that the moisture which exudes from the decomposing meat or body does not soak right through, and forming a wet patch under the packet, so soften the paper as to allow small larvae to eat their way in and reach the meat. As soon as the outer part becomes wet, the packet should be wrapped up in several fresh sheets of newspaper; and this may have to be repeated several times. Although large numbers of eggs may be laid under the packet, as long as the outer layers are dry the larvae cannot make their way to the meat. When the special larvae are nearing maturity, they crawl out into the folds of the paper and pupate, so that it is necessary to examine the packet for such larvae every two or three days; larvae about to pupate can always be recognised by their yellowish-white colour and the absence of food in their alimentary tracts. Several mature larvae should be preserved, as noted above, the remainder allowed to pupate, and the puparia later removed and placed in tubes with well-fitting corks. From 24 to 36 hours after the flies have hatched they should be killed and pinned with their empty puparia; and all dead larvae, whether first, second or third stage, preserved in one tube containing 80 per cent. alcohol.

I have collected most of the Indian CALLIPHORINAE and their early stages by placing dead animals out in the open, and when a female of any species came to lay its eggs, it was carefully observed, and after a large number of eggs had been laid, in most instances the fly was caught, pinned and identified. The mass of eggs was then removed by cutting off a piece of tissue, so as not to injure the eggs; a few were then

placed separately in a dry tube in order to preserve the first-stage larvae as soon as they hatched, and the remainder of the eggs were placed in the mouth of a dead bird or animal, which was then wrapped up as explained above. Some second-stage larvae were collected about the second or third day, the third-stage larvae later, and finally the flies were bred out of puparia. In this way I was able to obtain the eggs, first, second and third-stage larvae, of a large number of the commoner Indian species; such material is extremely valuable for comparative studies.

This method of rearing the larvae of the semi-specific myiasis-producing larvae is very satisfactory. In the case of the specific myiasis-producing species, such as *Chrysomyia bezziana* or *Wohlfahrtia magnifica*, it is a mere waste of time attempting to rear their larvae in decomposing animal matter. They can only be reared to maturity in living tissues. It is therefore obviously necessary to be able to recognise the second-stage larvae of such a species as *Chrysomyia bezziana*—the first stage is very seldom found, as it is a very short one. The second-stage larva of *Ch. bezziana* is fortunately very characteristic, and I am not acquainted with any other species which has a similar larva. The segmental spines are extremely well developed and stand out as dark bands; the anterior spiracles consist of five finger-like processes; there is a well developed short accessory belt of spines at the sides of the abdominal segments 1 to 7 in front of the segmental bands, and the spines on the ventral pads consist of two separate rows. All the spines become weaker after the 5th segment, and are poorly developed on the 8th. The posterior stigmata are situated on a well developed plate, and consist of two rather broad straight slits directed backwards and inwards; the tracheae give off many branches after the vestibule, so that the 8th segment has a dark colour, owing to these showing through the integument.

If the case is one of rhinal, oral, aural or vaginal myiasis, the larvae should be removed by spraying the parts with glycerine, or even with a little weak chloroform water; it may be difficult to dislodge the larvae when they are high up in the accessory nasal sinuses, but it is nearly always possible to get a few. Medical officers in India have always been able to send me a considerable number of larvae from such cases. The mature larvae of *Ch. bezziana* when removed from the tissues should be placed in some earth in a cigarette tin and allowed to pupate.

With the help of the above key, medical and veterinary officers should find no difficulty in determining the genera to which the larvae belong, by simply examining the posterior stigmata with the aid of a pocket lens magnifying 15 times. The presence of fleshy processes on the larva points to its being either *Fannia*, *Aphiochaeta* or such CALLIPHORINAE as *Chrysomyia albiceps* or *varipes*, two Oriental and Australian blowflies. If the larva is smooth, note whether the stigmatic slits are curled or straight. If curled it belongs to the MUSCINAE, if straight, to either *Calliphora*, *Chrysomyia*, *Lucilia* or *Sarcophaga*. With the aid of the key, and the drawings accompanying these notes, the larva can be accurately placed in any of these genera. If there is any doubt as to whether the chitinous ring is complete or not, shave off the end of the 8th abdominal segment with the stigmata with a razor, and clear it in 10 per cent. caustic potash, and mount, after dehydration, in Canada balsam on a slide. The determination of the species should, in most cases, be left to a specialist.

All *Sarcophaga* larvae should be reared to maturity, and the adults hatched out and carefully pinned, especially the males, as there is no means at present of determining the larvae of these flies. Any such material would be most valuable.

In the case of the OESTRIDAE, all of which are specific myiasis-producing flies, success in hatching out the adults is only possible if the mature larvae, which have of their own accord left their host, can be obtained. Such larvae should be placed in some earth in a cigarette tin and should be handled as little as possible. The mature larvae of the OESTRINAE are usually much darker than the immature specimens; in others the skin becomes dark yellow and harder. Mature larvae can sometimes be obtained in places where their hosts are in the habit of lying up during the evening,

for it is usually then that they leave them. The camel bot larvae always leave their hosts in the evening, when the camels are feeding. They will be found buried in the earth and under leaves, etc.

In the case of recently killed wild animals, such as deer, antelopes, pig, wart-hogs, rhinoceroses, zebras, elephants, etc., if the observer has time, many larvae may be collected from the nose, accessory sinuses, throat, nasopharynx, skin, stomach and duodenum. The largest and the smallest larvae should be specially selected, for in this way the nearly mature third-stage larvae, and sometimes the second stage, will be obtained. The larvae should be placed in tubes until they can be preserved by killing them in boiling water or alcohol. I hope those who have opportunities while on *shikar* trips in Africa and India will collect any Oestrid larvae they may find and preserve them as described above and send them to Dr. Marshall. The hosts of many of these flies are gradually being exterminated, and with them these interesting insects will disappear before we have time to learn all there is to be learnt from their larvae.

The first-stage larvae of all oviparous OESTRIDAE can be obtained by collecting the eggs from the hairs, skins, tusks, trunk, etc., of their respective hosts, whether dead or alive. The hairs, or the piece of skin, should be cut off and placed in a dry tube with a well-fitting cork, and watched every day. In a few species the larvae hatch out of their own accord, such as those of *Gasterophilus veterinus* (*nasalis*), *Hypoderma bovis* and *H. lineata*; others again only require moisture, when they at once escape from the eggs, as in the case of the larvae of *Cobboldia elephantis*; and others again require friction as well as moisture, such as the larvae of *Gasterophilus intestinalis*. Recently Captain Cross, C.V.D., sent me a large number of horses' hairs with eggs of *Gasterophilus intestinalis* var. *bengalensis* from the legs of horses in the Punjab. The larvae could not hatch out when the eggs were only moistened; but as soon as they were compressed, the opercula broke away. This friction is applied by the tongue of the horse.

All such first-stage larvae should be dropped into hot 70 per cent. alcohol and placed in a small tube with a good cork, which must be paraffined in order to prevent the alcohol escaping.

In the case of the larviparous OESTRIDAE, such as the OESTRINAE, the first-stage larvae can only be obtained by catching a female, either when depositing its larvae at the entrance to the nose, or in the neighbourhood of its host, on the off chance that it may contain larvae ready to be extruded. The flies should be preserved in 70 per cent. alcohol, for the larvae can always be dissected out afterwards; and the fly can be identified from such spirit specimens. This also applies to species of *Wohlfahrtia* and *Sarcophaga*, for these flies are larviparous in habit.

In concluding these notes, I would like to take this opportunity of thanking all those who have given me material bearing on this subject. Owing to the long distance it will of course be impossible to send me living larvae, so that the breeding out of the flies will, in the first instance have to be carried out on the spot. But as more material other than Indian becomes available, it will be possible to give a complete description with a key to the larvae of the myiasis-producing Diptera, so that a Medical or Veterinary Officer when he comes across a case may be in a position to determine the species without having to breed out the fly; breeding experiments are always difficult, take up a lot of time, and, as often as not, fail. Medical and Veterinary Officers have unique opportunities of collecting the larvae of these flies and of studying their habits, but I believe many are deterred from doing so because there is no easily-accessible account of these interesting parasites of man and animals; I trust these notes will in some way fill this hiatus. And lastly, I would like to point out that comparative studies of the first, second, and third-stage larvae of these higher Diptera cannot but lead to a better knowledge of the relationships of the adults.

A REVISION OF THE MOSQUITOS OF THE PALAEARCTIC REGION.

By F. W. Edwards.

(*Published by permission of the Trustees of the British Museum.*)

For some years after the intensive study of mosquitos began in tropical countries, surprisingly little interest was taken in the European species, particularly those of Northern Europe. Ficalbi had published his monographic revision in 1896–99, but from then until 1914 very little further had been done ; the adults were assumed to be more or less known, though very few of the larvae had been described. Since 1914, however, a great deal of work has been done all over Europe, bionomic as well as systematic, and considerable advances have been made in every branch of our knowledge of these insects.

The present paper was commenced early in 1919, with the study of a number of large collections received at the British Museum from Italy (Mr. E. Hargreaves), Macedonia (Capt. J. Waterston), Palestine and Mesopotamia (Capt. P. J. Barraud), and Egypt (Major E. E. Austen). Shortly afterwards a correspondence with Dr. Wesenberg-Lund, of Copenhagen, made it evident that there were many more species in Northern Europe than had previously been supposed. I therefore determined to attempt a revision of the Palaearctic mosquito fauna, and with this end in view wrote to the Dipterists in charge at various continental museums, as well as some private collectors, for the loan of material for determination or re-determination. Collections were sent in response to my requests by Dr. R. Frey, Helsingfors Museum ; Dr. E. Bergroth, Jämsa, Finland ; Dr. Y. Sjöstedt, Stockholm Museum ; Dr. Wesenberg-Lund, Hillerod, Denmark ; Dr. G. Enderlein, Berlin Zoological Museum ; Dr. W. Horn, Berlin-Dahlem Entomological Museum ; Herren L. Oldenberg and B. Lichtwardt, Berlin ; M. E. Séguy, Paris Museum ; Dr. H. Zerny, Vienna Museum ; Dr. K. Kertész, Budapest Museum ; Prof. M. Bezzi, Turin ; and odd specimens were also received from Dr. Lundbeck, Copenhagen Museum ; and Dr. E. Martini, Hamburg. A further valuable collection was sent by Mr. S. Yamada from Japan in 1916, and additional Japanese and Chinese collections were made by Dr. W. A. Lamborn in 1921. To all who have helped me in this way I wish to express due thanks, as also to other correspondents and colleagues for help in other ways.

The publication by Dr. E. Martini of his admirable paper, " Über Stechmücken," in August 1920, and by Dr. Wesenberg-Lund of his equally excellent treatise on Danish mosquitos early in 1921, have to a great extent covered the ground which it was intended to investigate in this paper, and have also gone much further in giving an account of the life-history of the majority of the European species. The present paper, while not claiming to make any very considerable further contribution to our knowledge of these species, will serve to correlate and summarise the results of these and other workers, and by including the whole Mediterranean region give a rather more comprehensive view of the subject.

The geographical limits adopted here are those most usually given to the Palaearctic region, *i.e.*, Europe, North Africa, as far south as the tropic ; the Atlantic Islands ; Asia Minor ; North Arabia, including the head of the Persian Gulf ; North

Asia as far as the Himalayas; North China; Japan. Mosquitos have been more or less carefully collected over practically the whole of this area, the least known portions being perhaps North Russia and North and Central Siberia. Spain also has not yet been thoroughly worked. Iceland should be included in the area, but no mosquitos have yet been recorded or received from that country.

The study of the various collections enumerated above indicates that the mosquito fauna is fairly homogeneous over the greater part of the area, but there are two parts which, so far as this group of animals is concerned, would seem to be better classed in the Oriental region. These are the area immediately round the head of the Persian Gulf, and the southern islands of Japan, at least as far north at Tokio. In the former area there is a very large, perhaps a predominating admixture of Oriental forms, while round Tokio the fauna appears to be of an almost purely Oriental type. If these two areas had been excluded from consideration, the number of species dealt with would have been much less; but it was thought that the usefulness of this paper might be increased by keeping to the wider limits.

The total number of species dealt with is as follows:—

Anopheles, 19.
Uranotaenia, 2.
Rachionotomyia, 1.
Megarhinus, 3.
Theobaldia, 7.
Orthopodomyia, 1.
Taeniorhynchus, 1.
Aëdes, 38.
Armigeres, 1.
Lutzia, 1.
Culex, 20.

The faunistic relationship of these species may be analysed as follows:—

Intrusions from the Oriental Region.			Intrusions from the Ethiopian Region.	
In the West.	In the East.		In Algeria, etc.	In Egypt and Palestine.
A. stephensi.	*An. lindesayi.*	*Arm. obturbans.*	*An. costalis.*	*A. mauritianus.*
C. tritaeniorhynchus.	*U. bimaculata.*	*L. vorax.*	*Ae. vittatus.*	*A. pharoensis.*
C. vishnui.	*R. bambusa.*	*C. hayashi.*		*C. quasigelidus.*
C. fatigans.	*M. towadensis.*	*C. bitaeniorhynchus.*		*C. laurenti.*
	A. togoi.	*C. sinensis.*	In Mesopotamia.	*C. tritaeniorhynchus.*
	A. japonicus.	*C. tritaeniorhynchus.*		
	A. koreicus.	*C. vishnui.*		
	A. niveus.	*C. fatigans.*	*A. rhodesiensis.*	
	A. albopictus.			

The remaining 70 species may be said to comprise the true Palaearctic fauna (though a number of them spread into adjoining regions). As might be expected, there are considerable differences between the North European and the Mediterranean faunas. The former shows very strong affinities with the Nearctic fauna, and a considerable number of the species seem to be common to both Europe and North America, while others have obviously representative forms in the two regions. The species which I consider either identical or only varietally distinct are: *Anopheles maculipennis, Theobaldia alaskaensis, Aëdes dorsalis, A. lutescens, A. excrucians, A. alpinus, A. cataphylla, A. diantaeus, A. sticticus, A. punctor, A. communis, A. intrudens, A. pullatus, A. vexans, A. cinereus, Culex apicalis, C. pipiens.* Nearly all these species are already known to occur throughout Europe and Siberia, and the two faunas may therefore be assumed to have mixed at a recent date by way of Eastern Siberia and Alaska. In one or two cases (*e.g., Anopheles maculipennis*) there seems to be definite evidence that the European fauna is more closely allied to that of Western than that of Eastern North America.

The following may be considered representative species :—

Europe.	North America.
Anopheles plumbeus.	*A. barberi.*
Theobaldia annulata.	*T. maccrackenae.*
T. glaphyroptera.	*T. impatiens.*
T. morsitans.	*T. dyari.*
Orthopodomyia pulchripalpis.	*O. signifer.*
Taeniorhynchus richiardii.	*T. perturbans.*
Aëdes semicantans.	*A. stimulans.*
A. rusticus.	*A. trichurus.*
A. geniculatus.	*A. triseriatus.*

It is of special interest to note that none of the European species in this list are at present known from Asia.

As might be anticipated, few, if any, of the purely southern species have any clearly recognisable North American representatives, but some of them have wide extensions of their range into the Ethiopian and Oriental regions. The most noteworthy of such species are *Theobaldia longiareolata* and *Culex tipuliformis.*

In the more northerly parts of the region the dominant group is the subgenus *Ochlerotatus* of *Aëdes* ; the species of *Anopheles* which occur are all of the typical subgenus. Further south *Ochlerotatus* rapidly disappears, and begins to be replaced in part by species of *Culex,* and in part by other subgenera of *Aëdes,* while the Anophelines of the *Myzomyia* group become numerous.

I have endeavoured in this paper to revise the generic classification of the CULICIDAE on a sounder basis than has been used hitherto, by defining the genera primarily on characters which have no relation to sex. In previous papers I have tried to minimise the use of secondary sexual characters, as well as of the merely superficial characters of the scales, but found myself in some cases compelled to fall back upon these, or else on the male hypopygium. A closer study of the insects now enables me to point out what appear to be constant and important distinctions between most of the genera which are applicable equally to both sexes without being so artificial as the scale characters have been proved to be. Fortunately no changes are involved in our conception of the limits of the genera ; these had been already soundly established by the study of the larvae, and the new characters adduced only confirm most of the conclusions already arrived at by a study of the early stages.

Several of the new distinctions employed are to be found in the thoracic chaetotaxy, and to explain these clearly I give explanatory figures of the pleural bristles in *Theobaldia annulata* and *Aëdes geniculatus.* The most important bristles for taxonomic purposes I find to be those occurring on the area in front of the prothoracic spiracle. This area is almost entirely occupied by the proepimeron, but there is a small, more or less triangular area immediately adjoining the spiracle which is separated from the proepimeron by a well-marked ridge. The bristles which are found on this small area I speak of here as the *spiracular* bristles. When present they project backwards, covering and protecting the spiracle. When the spiracular bristles are absent, their function is often assumed by the *proepimeral* bristles, which are usually situated in a row near the posterior margin of the proepimeron ; it will sometimes be necessary to look closely in order to ascertain whether the bristles present are spiracular or proepimeral, or perhaps both ; their position relatively to the above-mentioned ridge is the deciding factor. The two groups are obviously not homologous.

The other groups of bristles on the pleurae are apparently of less importance, and are for the most part more hair-like. They are as follows :—*Pronotal,* on the prothoracic lobes. *Prosternal,* on the prosternal lobes ; a group which Christophers considers important in the ANOPHELINI, but which seems to be fairly constant throughout the CULICINI. *Post-spiracular,* a distinct group of some importance situated a little behind the prothoracic spiracle and below the margin of the mesonotum.

Pre-alar, a clump situated on the pre-alar prominence ; always present, but variable in number. *Sternopleural,* the row which is nearly always present, extending vertically across the mesepisternum and mesosternum, almost in a line with the row on the

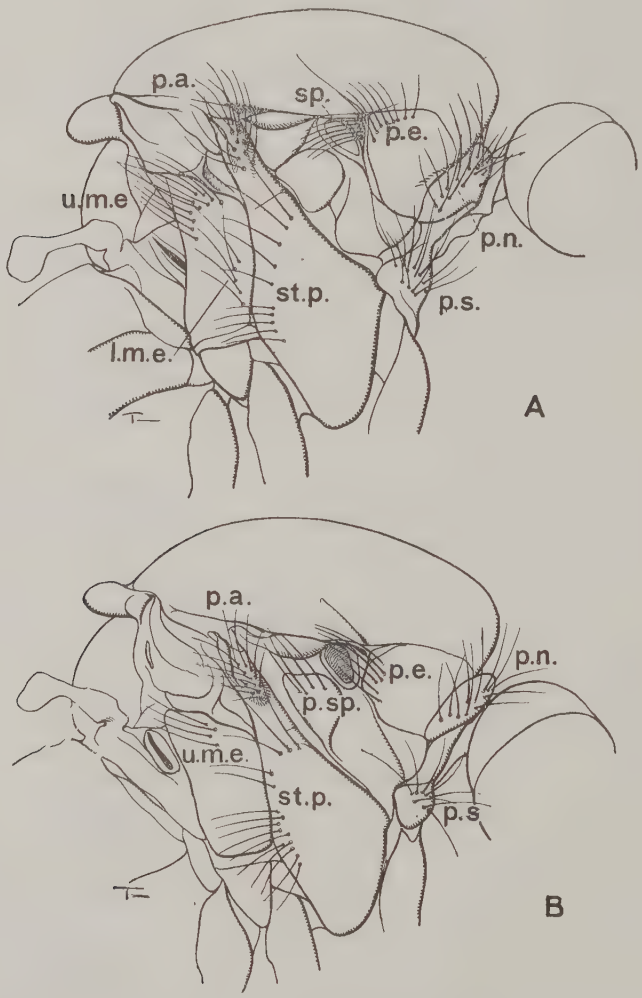

Fig. 1. Side view of thorax of (A) *Theobaldia annulata* and (B) *Aëdes geniculatus,* to show arrangement of pleural bristles. (Scales omitted.) Bristles: *p.n.*, pronotal; *p.s.*, prosternal; *p.e.*, proepimeral; *sp.*, spiracular; *p. sp.*, post-spiracular; *p.a.*, pre-alar; *u. m.e.*, upper mesepimeral; *l.m.e.*, lower mesepimeral, *st. p.*, sternopleural.

middle coxae. *Mesepimeral,* two groups whose position is indicated by the name ; the *upper mesepimeral* bristles form a distinct clump or tuft which is always present ; the *lower mesepimeral* are variable in number and have been used to distinguish the genera *Culex* and *Lutzia.*

I have studied also the mesonotal bristles, but although these vary greatly in number and development, I have not succeeded in discovering any differences which are of more than specific value. The same applies to the bristles of the legs, but those of the head sometimes offer useful generic characters. There are two great advantages which bristle characters have over scale characters. Firstly, they are obviously of much greater phylogenetic importance. Secondly, even when they are rubbed off they always leave a recognisable scar. A denuded specimen may even be more easy to examine than a perfect one, as the scales are sometimes liable to obscure the bases of the bristles.

In this paper I believe I have mentioned every name proposed for a mosquito taken within the region dealt with, but I have not as a rule given additional synonyms, nor have I attempted to unravel all the confusion caused by mis-identification, but have tried merely to give clear definitions of the specific concepts. A large number of the old descriptions are unrecognisable, and the types of many (some of Meigen's and all of Robineau-Desvoidy's) have apparently ceased to exist. Since, however, it is highly probable that the old names all apply to species which are known at the present day, I have endeavoured to form an opinion as to which species was most likely intended by the describer, rather than give a separate list of indeterminable species. I have not included Robineau-Desvoidy's *Culex flavovirens* and *C. viridis* in the synonymy, because I consider it obvious that they were CHIRONOMIDAE. Linnaeus' *Culex vulgaris* may very likely have been a species of *Aëdes*, but has been considered by Dyar and Knab to be a *Simulium*; it is therefore omitted. *Anopheles sacharovii*, *A. pseudopictus* var. *flerowi*, Portch., and *A. superpictus* var. *vassilievi*, Portch., referred to by Russian writers (see Review of Applied Entomology, B, ii, p. 108, and iii, p. 196), do not appear to have been described; at any rate I have been unable to trace the descriptions. For references to the original publications of *Culex annulatus*, de Fourcroy, *C. niveus*, Eichwald, and *C. pallipes*, Waltl, I am indebted to Mr. C. Davies Sherborn, who has kindly allowed me access to his manuscript.

Tribe ANOPHELINI.

Genus **Anopheles,** Mg.

As the careful and detailed researches of Christophers have shown, there are two main sections of the genus *Anopheles*, differing in small but quite easily definable characters, both in the adult and in the larva, and undoubtedly to be regarded as representing a very early separation of the genus into two distinct stocks. This separation, according to Christophers, probably took place at least as early as the Cretaceous. It is both desirable and convenient to recognise this important conclusion in our nomenclature, and I therefore accept the divisions proposed by Christophers (Ind. Journ. Med. Res. iii, p. 383, 1915) as subgenera. I do not consider that the differences are sufficiently important or sharply defined to warrant the full generic separation of the two old-world groups, nor do I consider it possible to subdivide either of these groups in a satisfactory manner, since the connections between their component species are so intricate and the intergradations so complete. As Christophers has pointed out, the subgenus *Anopheles* shows much more real diversity among its members than the subgenus *Myzomyia*, but when the species of the whole world are taken into consideration it is impossible to recognise clearly-defined divisions.

The eggs of different species of *Anopheles* show remarkable variations in the structure of the air-floats, while these appear to be constant for each species; in some instances, indeed, this is so markedly the case that the egg-structure (when known) affords the readiest means of distinguishing closely allied forms. I have therefore considered it worth while to collect into one block all the published figures of the eggs of Palaearctic *Anopheles*. These, with the two or three new ones which

are added, comprise all the species dealt with in this paper, except *A. mauritianas* and *A. sergenti*. It will be noted that the species in which the air-floats have undergone great reduction are *A. plumbeus*, *A. elutus*, *A. multicolor* and *A. turkhudi*. Dr. G. A. K. Marshall suggests that this reduction may be connected with the habit

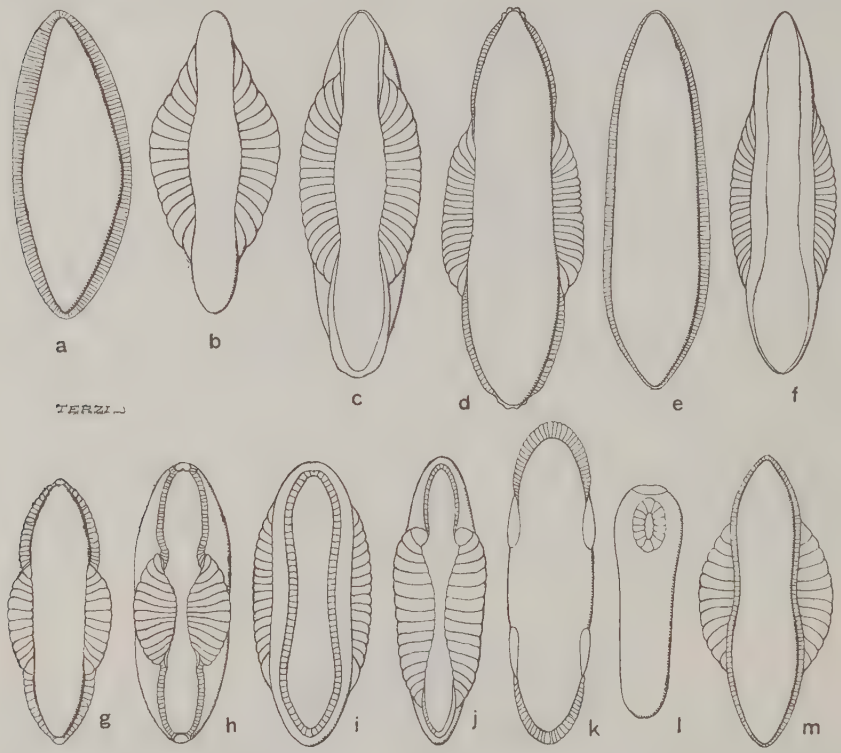

Fig. 1.— Eggs of Palaearctic species of *Anopheles*. *a*, *A. plumbeus*, Steph. (original); *b*, *A. algeriensis*, Theo. (after Sergent); *c*, *A. bifurcatus*, L. (after Martini); *d*. *A. maculipennis*, Mg. (original); *e*, *A. elutus*, sp. n. (original); *f*, *A. hyrcanus* (Pall.) (original); *g*, *A. pulcherrimus* Theo. (after Stephens and Christophers); *h*, *A. stephensi*, Theo. (after Stephens and Christophers); *i*, *A. costalis*, Theo. (after Patton); *j*, *A. rhodesiensis*, Theo. (after Patton); *k*, *A. multicolor*, Camb. (after Foley); *l*, *A. turkhudi*, Liston (after Stephens and Christophers); *m*, *A. hispaniola*, Theo. (after Sergent).

of breeding in water of high specific gravity (tanninised water in the case of *A. plumbeus*, saline water in the case of *A. multicolor*), in which large floats would perhaps not be necessary in order to keep the eggs on the surface during incubation. It is uncertain whether this explanation will apply to *A. elutus* and *A. turkhudi*.

Subgenus **Anopheles,** Christophers.

Ind. Journ. Med. Res. iii, p. 383 (1915).

Adult.—Cross-veins and bases of forks of wing-veins with dark scales. Costa largely dark (in Palaearctic species), with at most two pale spots, apart from a pale area in the apical fringe. Male hypopygium with two (rarely one or three) strong spines at the bases of the side-pieces, one or both of which are borne on a strong tubercle. Prosternal hairs usually numerous.

Larva.—Shaft of antenna with a branched hair (except in *A. plumbeus*). Palmate hairs lanceolate, without long terminal filament. Internal clypeal hairs generally close together.

The members of this subgenus exhibit considerable diversity, and some obviously fall together into groups, but when the species of the whole world are considered it does not seem profitable or even possible to recognise distinct subgenera. The nine Palaearctic species at present known may be distinguished by the following tables: —

Adults.

1. Wing-scales all dark; front femora cylindrical; female palpi slender, the scales appressed (*Anopheles*) 2
   Wings with many pale scales; front femora thickened at the base; female palpi and proboscis (except in *A. lindesayi*) shaggily scaled towards the base (*Myzorhynchus*) 6
2. Wing-scales uniform; base of upper fork-cell considerably nearer wing-base than that of the lower 3
   Wings normally with spots of darker, more densely aggregated scales; fork-cells somewhat shorter, their bases practically level 5
3. White frontal tuft absent; mesonotum unicolorous, with dark hair *algeriensis*, Theo.
   White frontal tuft present; mesonotum darkened at sides, with some pale hair and scales 4
4. Smaller, blacker species; a distinct patch of white scales on front of mesonotum .. .. *plumbeus*, Hal.
   Larger, browner species; scales on front margin of mesonotum narrower and not pure white .. .. *bifurcatus*, L.
5. Mesonotum unicolorous; wing-fringe all dark .. .. *elutus*, sp. n.
   Mesonotum darker at sides; fringe usually pale at tip of wing *maculipennis*, Mg.
6. Costa with only one pale spot (at the tip); hind femora with a conspicuous white pre-apical ring; front femora only slightly enlarged at the base *lindesayi*, Giles
   Costa with two distinct pale spots (normally); hind femora without pre-apical white ring; enlargement at base of front femora conspicuous .. 7
7. A white dot at base of costa, and a second near it .. .. .. *punctibasis*, sp. n.
   These dots absent 8
8. Fourth and fifth hind tarsal joints all white .. .. .. *mauritianus*, Grp.
   Fifth hind tarsal joint dark 9
9. Fourth hind tarsal joint dark except at the tip 10
   Fourth hind tarsal joint all white or whitish, *hyrcanus* var. *pseudopictus*, Grassi
10. Wing-markings usually more sharply defined; basal half of costa with dark scales only .. .. *hyrcanus*, Pall.
    Wing-markings more blurred; basal half of costa with some pale scales on its inner edge .. .. *hyrcanus* var. *mesopotamiae*, Chr.

Male Hypopygium.

1. Base of side-piece with only one strong spine .. .. *algeriensis*, Theo.
   Base of side-piece with more than one strong spine 2
2. Base of side-piece with three spines, two of them branched *bifurcatus*, L.
   Base of side-piece with two spines, both simple 3
3. Spines of claspette approximated, but not fused 4
   Spines of claspette fused into a spatulate process 5

4. Aedoeagus short and broad, without leaflets .. .. .. *plumbeus*, Hal.
   Aedoeagus long and narrow, with leaflets at the tip
   maculipennis, Mg. ; *elutus*, sp. n.
5. Spatulate process long and narrow ; ninth tergite without definite processes ; long hair at middle of side-piece moderately developed
   lindesayi, Giles
   Spatulate process shorter and broader ; ninth tergite with distinct processes ; long hair at middle of side-piece stouter, almost spine-like .. 6
6. Processes of ninth tergite short and broad .. .. *punctibasis*, sp. n.
   Processes of ninth tergite elongate .. *hyrcanus*, Pall. ; *mauritianus*, Grp.

Larvae.

1. A row of six large plumose hairs across middle of head 2
   These hairs vestigial, simple .. .. *plumbeus*, Hal.
2. Outer anterior clypeal hair thickly branched, dendriform 3
   Outer anterior clypeal hair simple or slightly branched .. *bifurcatus*, L.
3. Innermost shoulder-hair branched from base or nearly .. *mauritianus*, Grp.
   Innermost shoulder-hair branched only at tip, if at all 4
4. Palmate hairs on abdominal segments i–vii (always ?) .. *hyrcanus*, Pall.
   Palmate hairs on abdominal segments iii–vii only
   elutus, sp. n. ; *maculipennis*, Mg.

The larvae of *A. algeriensis* and *A. lindesayi* are insufficiently described for inclusion in the above table ; that of *A. punctibasis* is not yet described.

1. **Anopheles (Anopheles) algeriensis,** Theo. (fig. 2, b).

Anopheles algeriensis, Theobald, Mon. Cul. iii, p. 21 (1903).
Anopheles lukisi, Christophers, Ind. J. Med. Res. iv, p. 120 (1916).

Easily distinguished by the unspotted wings and the absence of a distinct tuft of long white scales on the front of the head. The mesonotum is uniformly dull light brown, and clothed with dark hair only, the small yellowish hairs or hair-like scales which are found in *A. bifurcatus* being absent in this species. In the female the second segment of the palpi is considerably longer than the first or the third and fourth together.

The male hypopygium, which has not as yet been described, is very distinct. The processes of the ninth tergite (ventral processes of Christophers) are very short, less than half as long as the breadth of the tergite. The side-pieces have a strongly differentiated bristle on the inner side near the tip, as in *A. bifurcatus ;* there is a single very strong basal spine, situated on a large tubercle, with its tip bent ; the outer basal spine is absent or represented only by one or two scarcely differentiated and inconstant bristles. The claspettes are trilobed, the first lobe bearing two or three strong, pointed, closely approximated spines, the second several short hairs, the third (innermost) three nearly equal, moderately strong bristles. The aedoeagus bears two or three pairs of long delicate leaflets at its tip.

The larva is unknown. Sergent, indeed, gives a short, incomplete description and some figures of a larva which he supposes to be *A. algeriensis*, but he was unaware of the real distinctions between *A. algeriensis* and *A. bifurcatus*, and his statements are insufficient to enable us to decide which of these species he had before him, or whether he had both. Sergent's figure of the egg is reproduced in fig. 2, *b* ; it is not improbable, however, that this really represents the egg of *A. bifurcatus*.

The type of *A. lukisi* shows faint traces of pale banding on the hind tarsi ; in the Mediterranean specimens the tarsi are entirely dark, but there appear to be no other differences. The colour of the mesonotum varies from yellowish to rather dark brown.

The species has a rather close resemblance to the Oriental *A. aitkeni*, and, as suggested by Barraud, it is probable that the specimens of *A. aitkeni* recorded from Palestine were really *A. algeriensis*. *A. aitkeni* is certainly a distinct species, since the upright scales of the head are very much narrower than in *A. algeriensis*, and the side-pieces of the hypopygium have two distinct basal spines.

Distribution.—Algeria (*Sergent*); Italy (*Hargreaves*); Macedonia (*Waterston*); Palestine (*Austen, Barraud*); Egypt (*Austen*); Mesopotamia (*Christophers*).

2. **Anopheles (Anopheles) bifurcatus,** L. (fig. 2, c).

Culex bifurcatus, Linnaeus, Syst. Nat. Ed. x, p. 603 (1758).
Culex claviger, Meigen, Klass. u. Beschr. i, p. 4 (1804).
Culex trifurcatus, Fabricius, Ent. Syst. iv, p. 401 (1794).
Anopheles villosus, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii, p. 411 (1827).
Anopheles grisescens, Stephens, Zool. Journ. xii (1828).
Anopheles antennatus, Becker, Mitt. Zool. Mus. Berlin, ii, p. 68 (1903).

This species varies a good deal in size and colour; small dark specimens might be mistaken for *A. plumbeus* and small light ones for *A. algeriensis*. Apart from the male hypopygial characters, which are absolutely diagnostic, *A. bifurcatus* may readily be separated from *A. plumbeus* and *A. algeriensis* by the other characters mentioned in the key.

The larva, which has been fully described by Lang, occurs generally in clean water with some weed, in rather shady situations; in the Mediterranean region it is frequently found in wells. The winter is passed in the larval stage, the adults dying off in the late autumn and the first brood appearing again in early spring.

A. bifurcatus is less domestic than *A. maculipennis* and does not so readily enter houses, but bites freely in the open.

Distribution:—Throughout Europe, North Africa (except desert regions) and Asia Minor. Turkestan (*Vassiliev*). Not found as yet further east. Apparently rarer in the far north.

South European specimens are commonly smaller than those from Central and North Europe, but are not otherwise distinguishable.

3. **Anopheles (Anopheles) plumbeus,** Stph. (fig. 2, a).

Anopheles plumbeus, Stephens, Zool. Journ. iii, p. 503 (1828).
Anopheles nigripes, Staeger, Kroyer's Nat. Tidschr. ii, p. 552 (1839).

The general black colour, densely and uniformly scaled wings, white scales on front of mesonotum, conspicuously hoary stripe down centre of mesonotum, and conspicuous white frontal tuft, will suffice to distinguish this species from those with which it might be confused.

The larva and egg have been described by Lang, Eysell, and Carter and Blacklock. *A. plumbeus* is the only species in the Palaearctic fauna which is known to breed in rot-holes in trees, and the very striking characteristics of the larva all seem to be correlated with this habit. As has already been pointed out by Christophers, tree-hole larvae of different genera of mosquitos commonly show three forms of modification: (1) a reduction of the hairs on the head, and especially of the small bristles on the antennae; (2) an increase and enlargement of the hairs on the thorax and abdomen; and (3) a development of chitinous structures on the last few abdominal segments. All these points are well illustrated by *A. plumbeus*. The tree-holes in which these larvae are found are frequently (perhaps usually) dark, and it may be supposed that the sense of sight would be of little value to the inhabitants of such places, while that of touch would attain a greatly enhanced importance, since the

mosquito larvae have a number of predaceous enemies living with them. Possibly this may help to explain the development of hairs on the soft parts of the body, though their reduction on the head is not so easy to account for. The development of additional chitinous plates may be merely a chemico-physical reaction to the excess of tannin in the water.

Whatever may be the use of these larval modifications, it seems certain that they are due to environmental conditions (since they are shown by species in totally unrelated genera), and therefore the genus *Coelodiazesis*, founded solely on these characters, cannot be satisfactorily maintained.

Distribution.—Throughout Europe, wherever there are many deciduous trees, in which rot-holes can form. Not yet recorded with certainty from North Africa or Asia, except one from Katmia, Cilicia (*Lt.-Col. Lelean*, recorded by Christophers).

The Himalayan species *A. barianensis*, James, has been referred to by Christophers as identical with *A. plumbeus*, but there are small differences: in *A. barianensis* the white scales on the mesonotum extend further (almost half-way from the front) and the femora and tibiae are conspicuously white at the tips, whereas in *A. plumbeus* they have scarcely a trace of white. As there are also small distinctions between the larvae, it will probably be best to regard the two as distinct species, occupying separate geographical areas in the Palaearctic and Oriental regions. The type has also a North American representative in *A. barberi*, Coq., which is distinct from both the old-world forms, though closely resembling them.

4. **Anopheles** (**Anopheles**) **maculipennis**, Mg. (fig. 2, d).

Anopheles maculipennis, Meigen, Syst. Beschr. i, p. 11 (1818).
Culex claviger, Fabricius (*nec* Meigen), Syst. Antl. p. 35 (1805).
Anopheles occidentalis, Dyar & Knab, Proc. Biol. Soc. Wash. xix, p. 159 (1906); Howard, Dyar & Knab, Mosq. N. & C. Amer. iv, p. 1026 (1917).
Anopheles lewisi, Ludlow, Psyche, xxvii, p. 74 (1920).
Anopheles selengensis, Ludlow, Psyche, xxvii, p. 77 (1920).

This could not easily be confused with any other Palaearctic species except *A. elutus*; from this it differs in several small details of coloration, as indicated in the key. The pale area in the fringe at the tip of the wing is diagnostic of *A. maculipennis*, when it is present, but can only be seen in perfect specimens, the fringe at the wing tip being very easily denuded; moreover, the fringe is entirely dark in some individuals, and as the wing-spots also vary somewhat in intensity, the distinction between the adults of these two species is not very clearly marked. Perhaps the best distinction between the two species is in the colour of the scutum, that of *A. maculipennis* having a broad brown or blackish-brown stripe on each side, as in *A. bifurcatus* and *A. plumbeus*.

According to Wesenberg-Lund the Southern European race of *A. maculipennis* is smaller than the Northern. The difference, if it exists, is very slight, and is only to be found in the *average* measurement, since many Mediterranean specimens which I have seen are quite large. Dyar (in correspondence) also maintains that there is a minute difference in the hypopygia between specimens from France and Siberia and those from Hungary. I am unable to confirm this, and consider that the small amount of variation which does occur is individual only. Mounts of male hypopygia of specimens from Britain, Macedonia and Constantinople show no difference whatever.

In my opinion the Western North American *A. occidentalis* is specifically identical with *A. maculipennis*. I can discern no difference in the larvae; the adults are alike in all external features, and the only demonstrable difference in the male hypopygia is that the two outer spines on the claspette are both pointed in *A. occidentalis*, while one or both of them are blunt-ended in *A. maculipennis*. Such a distinction seems to me inadequate even for varietal separation. The egg of *A. occidentalis* is as yet undescribed, and may differ from that of *A. maculipennis*, but

I do not anticipate that such will be found to be the case. In any event *A. occidentalis* is much closer to *A. maculipennis* than is the Eastern North American *A. quadrimaculatus*, which differs in larva, hypopygium, and adult coloration. This is a fact of considerable interest, and is in line with what has been found in the genus *Aëdes*.

The early stages have been described in detail by Nuttall and Shipley, Lang and others. The larvae are found most commonly in open, weedy water in low-lying districts, sometimes in brackish water near the coast.

Distribution.—Throughout Europe, from the Arctic to the Mediterranean ; North-West Africa (except desert regions) ; and across Siberia to North-Western America ; also recorded by Christophers from Upper Mesopotamia.

5. **Anopheles (Anopheles) elutus,** sp. n. (fig. 2, e).

Anopheles sp., Christophers, Ind. J. Med. Res. vii, p. 711 (1920).
Anopheles maculipennis var., Barraud, Bull. Ent. Res. xi, p. 389 (1921).

Differs from *A. maculipennis* as follows : No trace of a pale spot in the fringe at the tip of the wing, the fringe being uniformly dark. Dark spots at the bases of the fork-cells and at cross-veins very poorly developed, often hardly perceptible, especially in the male. White frontal tuft small, rather inconspicuous. General coloration of the body rather lighter than in *A. maculipennis*, the sides of the scutum not any darker than the middle. Male hypopygium apparently identical with that of *A. maculipennis* in structure, but the ninth tergite less strongly chitinised relatively to the rest of the organs. Egg without lateral float-cells, evenly fringed all round as in *A. plumbeus*, but resembling *A. maculipennis* in its more elongate shape.

Larva apparently identical with that of *A. maculipennis*.

Type, a male in the British Museum reared from larva taken in marsh at Kishon, Palestine (*Capt. P. J. Barraud*).

The credit for the recognition of this species belongs to Major Christophers, who was the first to obtain the eggs. These are so different from those of *A. maculipennis* that it is impossible to regard the two forms as varieties of one species, notwithstanding the identity of the larvae and the close similarity between the adults. Major Christophers' observation has been amply confirmed by Capt. Barraud, who reared the species in Palestine, and presented material of all stages to the British Museum.

Distribution.—Mesopotamia (*Christophers*) ; Palestine (*Barraud*) ; Syria (*Barraud*) ; Macedonia (*Waterston*) ; Cyprus (*Dr. G. A. Williamson*) ; Transcaspia (Amudaria, *C. Ahnger*, in coll. Helsingfors Mus.) ; West Caspian (Adzikabul, near Baku, *per Col. Wenyon*) ; Steiermark (Admont, *Strobl.* ; in coll. *L. Oldenberg*) ; W. Persia (Quritu, *H. E. Shortt*).

In Palestine, Lower Mesopotamia and Transcaspia this species entirely replaces *A. maculipennis*, but in Macedonia the two occur together. *A. elutus* appears to be absent from Central and Northern Europe.

6. **Anopheles (Anopheles) lindesayi**, Giles.

Anopheles lindesaii, Giles, Gnats, p. 166 (1900).

A very well-marked species, with no close ally, unless the Japanese and Formosan forms are regarded as distinct. In several respects it is intermediate between the *Anopheles* and *Myzorhynchus* groups ; the transition is perhaps made more complete by *A. gigas*.

A. lindesayi is usually found at high altitudes and breeds in mountain streams.

According to Christophers' description and figure the ninth tergite of the male hypopygium is broad and shield-like, but in the Japanese male I have examined it has the usual narrow form, a narrow, curved strip, the ends being pushed out but

not forming definite processes. This may perhaps indicate a specific difference from the Indian form, though I cannot find any other characters in the adult to support such a conclusion.

This is possibly the so-called new species recently recorded (but not named) from Japan (see Tropical Diseases Bulletin, xvi, 1920, p. 106).

Distribution.—Mountains of India; Formosa (*Koidzumi*); Japan (Nagasaki, *Lamborn*).

7. **Anopheles (Anopheles) punctibasis,** sp. n.

Closely related to *A. hyrcanus* (Pall.), but differs in the following particulars:—Average size somewhat larger (♂ 4·5 mm., ♀ 5·5 mm. in length of wing); wings more distinctly mottled in naked-eye appearance than in the most brightly-marked *A. hyrcanus*. Antennae slightly but distinctly more slender than those of *A. hyrcanus* except for the first joint, which is distinctly stouter. Scales of antennae light brown and confined to the torus and the first two flagellar joints (in *A. hyrcanus* they are white and extend to the fourth or fifth flagellar joints). Palpi normally entirely black-scaled. All the tibiae, the first three joints of the front and middle tarsi, and the first four joints of the hind tarsi, narrowly but distinctly whitish-ochreous at the base as well as at the tip. A white dot at the extreme base of the costa, and a second immediately beyond the humeral cross-vein. Dark and light areas on veins sharply defined, no intermixture of light and dark scales except to a very slight extent on the third vein. Processes of ninth tergite of male hypopygium very short and broad, almost semicircular in form (hypopygium otherwise much like that of *A. hyrcanus*).

Distribution.—Japan: Nagasaki, 8–19.v.1921, 2 ♂ (including type), 5 ♀ reared from pupae found in a muddy shaded pool in company with *Culex hayashi*; Yokohama, vi.1921, 1 ♀ reared from larva (*Dr. W. A. Lamborn*).

The sum of the characters enumerated above seems to be quite sufficient to distinguish this form specifically from *A. hyrcanus*, though the close relationship is evident. The black-scaled palpi at first sight afford an easy means of distinction, but the Yokohama specimen has narrow white rings at the articulations and a distinct white tip to the last joint.

8. **Anopheles (Anopheles) hyrcanus,** Pallas (fig. 2, f).

Culex hyrcanus, Pallas, Reise durch versch. Prov. d. Russ. Reichs. i, p. 475 (1771).
Anopheles sinensis, Wiedemann, Aussereurop. zweifl. Ins. i, p. 547 (1828).
Anopheles pictus, Loew, Dipt. Beitr. i, p. 4 (1845).
Anopheles pseudopictus, Grassi, Atti R. Acc. Lincei, Rendic. viii, 1, p. 102 (1899).
Anopheles sinensis var. *mesopotamiae*, Christophers, Ind. J. Med. Res. iii, p. 196 (1916).

Easily distinguished from all other species in the Palaearctic fauna, except *A. punctibasis* and *A. mauritianus*, by the distinctly swollen front femora. This character was pointed out by Loew in his description of *A. pictus*, and together with the shaggily-scaled female palpi forms the best distinguishing mark of the *Myzorhynchus* group, the character of the ventral scale-tuft, on which the group was originally founded, being quite unreliable. The relation with the *Anopheles* group (in the strict sense) is however, obviously close; there is no definable difference in the larvae or hypopygia, and the colour differences are bridged by such species as *A. gigas*. I therefore do not admit *Myzorhynchus* as a distinct subgenus.

A. hyrcanus is a variable species in many respects, and shows a strong tendency to the production of local races. In the Oriental region some of these may be said to have reached specific differentiation (*e.g.*, *A. separatus*, Leic.), but this can hardly be said of the Palaearctic forms, at least with our present knowledge of them.

Christophers seems inclined to distinguish the var. *mesopotamiae* on account of a slight difference in the shape of the processes of the ninth tergite of the male hypopygium, but this distinction is no more constant than the colour characters which he adduces to separate *mesopotamiae* from *hyrcanus*. The form inhabiting Japan and Eastern Siberia has the wing-markings blurred somewhat as in the var. *mesopotamiae*, but the general coloration is much darker. The var. *pseudopictus* is at first sight sharply distinguished by its pale fourth hind tarsal joint (one Macedonian example has the third joint also broadly white at the tip), but the paleness in some specimens is only visible in certain lights, and there appears to be no other distinction between the two forms. The fifth hind tarsal joint in *pseudopictus* remains dark, but in Swellengrebel's *argyropus* from Sumatra both the fourth and the fifth joints are white; this condition seems to have been developed independently in *argyropus* and *mauritianus*, and, if so, *argyropus* should perhaps be regarded as an extreme form of *hyrcanus* rather than as an Oriental form of *mauritianus*.

A. hyrcanus is found chiefly in large marshes, especially near the sea. The larva has been described by Joyeux.

Distribution.—North Mediterranean coast from the Rhone delta to the Levant, and across Central Asia from the Black Sea coasts to Japan; also (in a darker variety) throughout the Oriental region. The var. *mesopotamiae* appears to be confined to the region at the head of the Persian Gulf; the var. *pseudopictus* has been found in Italy (*Grassi*); Macedonia (*Waterston*); Danube delta (*Leon*); Transcaspia (Tedjen, *C. Ahnger*).

9. **Anopheles mauritianus**, Grp.

Anopheles mauritianus, Grandpré, Planters' Gazette Press (1900).
Anopheles paludis, Theobald, Royal Soc., Rept. Malaria Com. p. 75 (6th July, 1900).

This is the African representative of *A. hyrcanus*, from which it differs almost solely in the generally blacker colour and the white tip of the hind tarsus. The range of variation of the two forms is, however, quite distinct, and it is no doubt justifiable to regard them as separate species. Christophers distinguishes the hypopygium from that of *A. hyrcanus* by the absence of leaflets on the aedoeagus, but either he was mistaken in his observation or the species is variable in this respect, since delicate leaflets are certainly present in those which I have examined.

Like its ally *A. hyrcanus*, this species lives chiefly in large swamps, especially near coasts, and is a poor carrier of malaria.

Distribution.—Tropical Africa, extending into the Palaearctic region only in the south-eastern Mediterranean, where it occurs in the Nile delta and in the marshes on the Palestine coast (*Barraud*).

Subgenus **Myzomyia** (Blanchard), Christophers.
Ind. Journ. Med. Res. iii, p. 383 (1915).

Adult.—Cross-veins and bases of forks of wing-veins with light scales (except in *A. rhodesiensis*). Costa with four or more pale spots. Male hypopygium with a group of several (4–6) stiff bristles at the base of each side-piece, none of which are borne on tubercles or otherwise differentiated. Prosternal hairs nearly always reduced.

Larva.—Shaft of antenna without a branched hair. Leaflets of palmate hairs generally with long terminal filament. Internal clypeal hairs rather wide apart.

The members of this subgenus, though showing a great total range of ornamentational characters, are really all much more closely allied than the species of the subgenus *Anopheles*. The male hypopygia are almost identical throughout the subgenus, the minute distinguishing characters given by Christophers being in some

cases of very uncertain value; the species most easily recognisable as regards hypopygial structure are those (*pulcherrimus*, *multicolor*) which have no leaflets on the aedoeagus, but it is impossible to consider a common lack of these structures as indicating relationship. The larvae also are extremely similar and difficult to distinguish.

Adults.

1. Abdomen densely scaly; the scales forming lateral tufts on each segment; last hind tarsal joint white; female palpi shaggily scaled .. 2
   Abdomen without lateral scale-tufts; last hind tarsal joint dark; female palpi with most of the scales appressed 3
2. Fourth hind tarsal joint all white .. .. .. *pulcherrimus*, Theo.
   Fourth hind tarsal joint mostly dark .. .. *pharoensis*, Theo.
3. Femora and tibiae pale-spotted 4
   Femora and tibiae not pale-spotted; abdomen without scales 5
4. Abdomen scaly almost to the base .. .. *stephensi*, Liston.
   Abdomen without scales, except on cerci .. .. .. *costalis*, Theo.
5. Pale wing-markings confined to costa and first vein .. ..*rhodesiensis*, Theo.
   Pale markings on all wing-veins 6
6. Tip of last palpal joint white-scaled 7
   Tip of last palpal joint black-scaled 8
7. Thorax with hairs only; last two white rings of female palpi quite narrow .. .. *sergenti*, Theo.
   Thorax with narrow scales as well as hairs; last two white rings of female palpi rather broad .. .. *superpictus*, Grassi.
8. Thorax with hairs only; male aedoeagus with leaflets (*turkhudi*, Theo.), *hispaniola*, Theo.
   Sides of mesonotum with distinct narrow scales 9
9. Male aedoeagus with leaflets .. .. *turkhudi* var. *persicus*, n.
   Male aedoeagus without leaflets .. .. *multicolor*, Camb.

Larvae.

1. Outer clypeal hair branched 2
   Outer clypeal hair simple 3
2. Palmate tufts on abdominal segments i–vii; outer clypeal hair thickly branched .. .. *pharoensis*, Theo.
   Palmate tufts on abdominal segments iii–vii; outer clypeal hair less branched .. .. *pulcherrimus*, Theo.
3. A rudimentary palmate tuft on first abdominal segment *costalis*, Theo.; *rhodesiensis*, Theo.
   This tuft absent 4
4. Posterior clypeal hair short; innermost shoulder-hair much branched *stephensi*, Liston.
   Posterior clypeal hair long 5
5. Innermost shoulder-hair much branched, plumose .. *superpictus*, Grassi.
   Innermost shoulder-hair slightly branched towards tip *multicolor*, Camb.; ? *hispaniola*, Theo.; ? *turkhudi*, Theo.

Good distinctions between some of the above larvae have yet to be discovered; possibly some may be found in the markings of the head. The larvae of *A. rhodesiensis*, *A. hispaniola* and *A. turkhudi* have not been fully described, and the British Museum does not possess sufficient material from which to supplement the descriptions.

10. **Anopheles (Myzomyia) pulcherrimus,** Theo. (fig. 2, g).

Anopheles pulcherrimus, Theobald, Proc. R. Soc. lxix, p. 369 (1902).

A very well-marked species, easily distinguished from all others in the Palaearctic fauna, except *A. pharoensis,* by having the abdomen densely covered with broad flat scales, rather loosely applied and forming distinct lateral tufts. The front femora are slightly swollen near the base, and in this point, as well as in the shaggily scaled female palpi, *A. pulcherrimus* and *A. pharoensis* seem to show some approach to *A. hyrcanus*; but the type of wing-markings and the structure of the male hypopygium are typical of the subgenus *Myzomyia.*

The early stages have been described by Vassiliev.

Distribution.—Semi-arid regions of south-western Asia, from Turkestan and the Punjab to Lower Mesopotamia.

11. **Anopheles (Myzomyia) pharoensis,** Theo.

Anopheles pharoensis, Theobald, Mon. Cul. i, p. 169 (1901).
Anopheles maculicosta, Becker, Mitt. Zool. Mus. Berlin, ii, p. 69 (1903).

Very similar to *A. pulcherrimus,* but is somewhat larger and has a broad dark ring on the fourth hind tarsal joint; usually also there is a pair of conspicuous black spots about the middle of the mesonotum, which are not seen in *A. pulcherrimus.* In both species the wing-membrane is deeply stained in the areas occupied by the main patches of dark scales. A similar condition is seen in some American species, and to some extent discounts Christophers' theory that all the pale markings of *Anopheles* wings arose by bleaching from a primitive, uniformly dark condition.

Distribution.—Essentially an Ethiopian species, being widely spread, though not common, in tropical Africa, and occurring in Madagascar. Common in Lower Egypt, and occurring rarely in Palestine (*Barraud*).

12. **Anopheles (Myzomyia) stephensi,** Liston (fig. 2, h).

Anopheles stephensi, Liston, Ind. Med. Gaz. xxxvi (1901); Christophers, Ind. J. Med. Res. iii, p. 481 (1916).

The femora and tibiae are conspicuously spotted with white, and the abdomen is almost covered with scales; the scales are narrow, and less dense than those of *A. pharoensis* and *A. pulcherrimus,* and never form lateral tufts. None of the allied Oriental or Ethiopian species (*A. maculatus, A. willmori, A. maculipalpis, A. theobaldi,* etc.) appear to have occurred within the area under discussion, and *A. stephensi* need not therefore be compared with them for our present purpose.

Distribution.—An Indian species occurring in a localised area round Basra, at the head of the Persian Gulf (*Barraud* and *Christophers*).

13. **Anopheles (Myzomyia) costalis,** Theobald (fig. 2, i).

Anopheles costalis, Theobald, Mon. Cul. i, p. 157 (1901).
? *Anopheles costalis,* Loew, Berlin. ent. Zeitschr., x, p. 55 (1886).
Anopheles arabiensis, Patton, J. Bombay Nat. Hist. Soc. xvi, p. 625 (1905).

The spots on the femora and tibiae vary in number and intensity, but are always present, and together with the absence of abdominal scales render the species an easy one to identify when Palaearctic forms alone are considered. The female palpi have three whitish rings, the terminal one broad and including the whole of the last joint.

I am informed by Dr. Enderlein that Loew's type of *A. costalis* is not now in his collection in the Berlin Zoological Museum.

Distribution.—Essentially an Ethiopian species, throughout which region it is abundant. I only include it among the Palaearctic species on the strength of a single female in the Paris Museum captured in Algeria (locality not noted) by M. E. Roubaud. It does not appear to have been recorded from Egypt, though there seems no reason why it should not spread there from the south.

14. **Anopheles (Myzomyia) rhodesiensis,** Theo. (fig. 2, j).

Anopheles rhodesiensis, Theobald, Mon. Cul. i, p. 184 (1901).
Anopheles d'thali, Patton, J. Bombay Nat. Hist. Soc. xvi, p. 627 (1905).

This species could not be confused with any other in the Palaearctic fauna, although the darkest varieties of the African *A. funestus* approach it rather closely. A detailed description has been given by Christophers (1915), who records it from Arabia, Baluchistan and Quetta. Its occurrence in Baluchistan is the only reason for including it in this paper. It occurs also in widely separated parts of tropical Africa.

15. **Anopheles (Myzomyia) superpictus,** Grassi (fig. 3).

Anopheles superpictus, Grassi, Reale Accad. Lincei., p. 78 (1900).
Pyretophorus palestinensis, Theobald, Mon. Cul. iii, p. 71 (1903).
Pyretophorus nursei, Theobald, Mon. Cul. iv, p. 66 (1907).
Pyretophorus cardamitisi, Newstead & Carter, Ann. Trop. Med. iv, p. 379 (1910).
Anopheles superpictus var. *macedoniensis,* Cot & Hovasse, Bull. Soc. Path. Exot. x, p. 890 (1917).

Distinguished from the nearly allied *A. multicolor* by the broad white tips to the female palpi. In both species the scutum bears distinct scales, at least at the sides. The wing markings of *A. superpictus* are very variable, the pale costal spots being sometimes much reduced. According to Ficalbi the tarsi are faintly ringed with

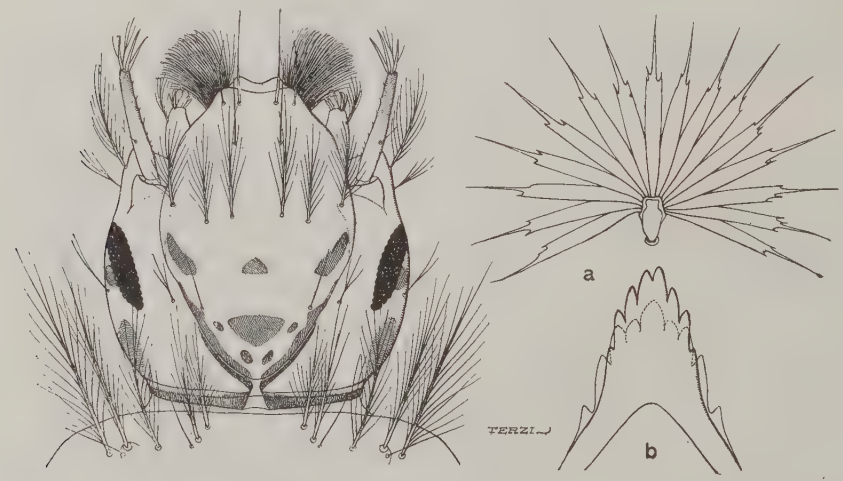

Fig. 3. Larva of *Anopheles superpictus,* Grassi: *a,* palmate tuft; *b,* mentum.

pale at the joints, when viewed through a lens. This is certainly true of a few of the specimens I have examined, but the majority have the tarsi entirely dark. I think, however, that there is no doubt that *A. superpictus* and *A. palestinensis* are the same species.

The larva has not been fully described. It may be diagnosed as follows :— Antennae with a minute single hair before the middle. Frontal hairs all simple, and all about equal in length, the inner anterior pair widely separated, the posterior pair almost immediately behind the inner anterior. Head markings fairly constant, arranged as in the figure, the spots small. Innermost shoulder hair plumose from base to tip, the hair next to it also plumose, but longer and with fewer branches. No rudimentary palmate hairs on thorax or on first abdominal segment ; a pair of small ones on the second segment, and fully developed pairs on segments 3–7 ; each fully developed hair has about 16 leaflets, which are lanceolate, with two or three jags beyond the middle, forming a rather indefinite shoulder ; terminal portion long, but not nearly as long as the basal. No difference could be detected between Macedonian and Indian specimens.

The species is said to be associated with mountainous districts, though by no means confined to high altitudes, and to be largely a stream-breeder.

Distribution.—Eastern Mediterranean region, from Italy to Macedonia and Palestine ; thence through Upper Mesopotamia and Persia to the Punjab. Also recorded from North Africa, though I have seen no specimens from there. Transcaspia (Firudza, *C. Ahnger*).

16. **Anopheles (Myzomyia) sergenti,** Theo.

Pyretophorus sergenti, Theobald, Mon. Cul. iv, p. 68 (1907).

This species very much resembles *A. superpictus,* but is rather smaller, and differs as indicated in the key. I have previously considered it identical with the Indian *A. culicifacies,* but whereas in *A. sergenti* there are four or five pale spots in the wing-fringe, in *A. culicifacies* there is never more than one. *A. sergenti* might equally well be regarded as a variety of the African *A. funestus,* which has several pale fringe-spots, but is much darker in general coloration, and has the third vein much less extensively pale. Detailed comparisons of these three species in all their stages are necessary before final conclusions can be reached as to their exact relationships.

Distribution.—Algeria (*Sergent*) ; Tunis (Tamerza, *Dr. M. Langeron*) ; Palestine (*Annandale, Barraud*).

17. **Anopheles (Myzomyia) hispaniola,** Theobald (fig. 2, m).

Myzomyia hispaniola, Theobald, Mon. Cul. iii, p. 49 (1903).
Pyretophorus myzomyfacies, Theobald, Mon. Cul. iv, p. 69 (1907).

Apparently only differs (in the adult) from *A. multicolor* in having leaflets present on the male aedoeagus, and hairs instead of narrow scales on the scutum ; according to Sergent & Foley the eggs of the two species are remarkably distinct. The wing-markings of both species (especially *A. multicolor*) are so variable that no constant difference can be found between them. *A. hispaniola* is quite indistinguishable, so far as I can see, from the Indian *A. turkhudi* in the adult state. The egg of *A. hispaniola* as figured by Sergent is, however, so different from that of *A. turkhudi* as figured by Christophers that, unless a mistake has been made by either author, it is impossible to regard the two as conspecific, especially as they are widely discontinuous in their distribution. The larvae also differ, according to the published descriptions, in the number of pairs of palmate hairs present ; but this requires confirmation, since the figure given by James and Liston is inconsistent with their description.

This species is apparently much less fond of desert conditions and saline water than *A. multicolor.*

Distribution.—S. Spain (*Macdonald*); Algeria (*Sergent*); S. Tunis (Tamerza, *Dr. M. Langeron*). Does not appear to occur in Egypt or Palestine.

References.—Sergent (Ed. & Et.), Ann. Inst. Pasteur, xix, 1905, p. 144; xx, 1908, p. 393.

18. **Anopheles** (**Myzomyia**) **turkhudi** var. **persicus,** nov.

The type male of *A. turkhudi* has no scales on the scutum, and has distinct leaflets on the aedoeagus. The same is true of all specimens I have seen from the Punjab, but a number sent me by Christophers from East Persia show distinct scales on the scutum, and are in fact indistinguishable externally from *A. multicolor*. They can hardly be that species, however, since the male aedoeagus bears distinct leaflets, as in *A. turkhudi* and *A. hispaniola*. Provisionally, therefore, I regard them as representing a distinct variety of *A. turkhudi*, which inhabits adjacent areas in the Punjab. The real relationships of all these forms can only be determined by a close study of their habits, early stages and distribution, and the early stages of this Persian form are not yet recorded.

19. **Anopheles** (**Myzomyia**) **multicolor,** Camb. (fig. 2, k).

Anopheles multicolor, Cambouliu, C. R. Acad. Sci. cxxxv, p. 704 (1902).
Pyretophorus chaudoyei, Theobald, Mon. Cul. iii, p. 68 (1903).
Pyretophorus cleopatrae, Willcocks (*nom. nud.*).
Anopheles impunctus, Dönitz, Zeitschr. f. Hygiene, xli, p. 67 (1902).

The adult does not differ appreciably from *A. hispaniola* and *A. turkhudi* except in having scales on the mesonotum (these scales, however, varying in number, width, and distinctness), and in the entire lack of leaflets on the male aedoeagus. *A. superpictus* has a similar thoracic ornamentation, but can easily be distinguished by its white-tipped palpi. Egyptian specimens commonly have the wings more extensively dark than those from Algeria, but, on the other hand, it is almost certain that Dönitz's *A. impunctus*, described from an abnormally pale specimen, is only a variety of this species.

The larva has been fully described by Foley (1912) and Langeron (1918). According to Langeron's figures the innermost shoulder-hair is only trifid at the tip, but in a number of specimens he has sent me from Tozeur, as well as in some skins sent by Capt. Barraud from Palestine, it is branched almost from the base and somewhat plumose. The head of the larva is extremely dark, the usual markings being all fused in most specimens into a large black patch which occupies the greater part of the head, leaving the front of the clypeus yellowish. The lower surface of the head, as well as the upper, is mainly blackish.

The egg as described and figured by Foley (reproduced in fig. 2, k) is very distinctive, and quite unlike that of *A. hispaniola* or *A. turkhudi*. The species is said to breed in highly saline desert pools, or in brackish water near the sea.

Distribution.—Desert regions of North Africa from Southern Algeria to Egypt; Palestine; Teneriffe. Not certainly known from further east or north.

Tribe Culicini.

I propose to revert to the old classification of mosquitos, and recognise only two tribes, the Anophelini and Culicini, including in the latter the Megarhinini and Sabethini. I am now convinced that Howard, Dyar and Knab were right in including *Megarhinus* in the Culicini and placing it somewhere near *Psorophora*; the modifications of the adults, though striking, are not fundamentally important. On the other hand, I am equally convinced that the tribe Sabethini cannot be maintained. Every character on which it has been attempted to define it breaks

down at some point or other. The character finally adopted by Howard, Dyar and Knab, that of the head bristles, is not indicated in *Eretmopodites*, which is unquestionably a Sabethine genus, while it is shown in some Culicine genera, notably *Megarhinus*. There is, no doubt, a group of genera (or more probably two or three independent groups) which are more closely related to one another than to other Culicines, but in adult structure there is certainly no hard and fast line to be drawn. In regard to the absence of the anal brush of the larva, which is the one common and outstanding feature of all SABETHINI, Colonel Alcock has suggested to me (I consider with great plausibility) that this may be an adaptive character, and therefore not necessarily indicative of relationship. As he points out, larvae living in small confined spaces, as do almost all of the SABETHINI, would not require the anal brush for swimming; and as it is absent in the first stage, there seems no reason whatever why its development should be proceeded with in the later stages. In confirmation of this view, it may be remembered that some of those species of *Aëdes* (*Stegomyia*) which live in small collections of water have the brush much less developed than in the free-living forms.

The ancestral form probably had pulvilli and spiracular bristles, narrow scales, and a non-carnivorous larva; partaking thus of some of the characters of *Theobaldia* and *Lutzia*; no such form is known, however.

Table of Genera of Palaearctic Culicine Mosquitos.

Adults.

1. Vein A_n (6th) ending below or a little before the level of the base of R_s (2nd); no microtrichia on wing-membrane .. .. *Uranotaenia.*
   Vein A_n ending well beyond the level of the base of R_2; wing membrane with microtrichia 2
2. Pulvilli absent 3
   Pulvilli present 9
3. Spiracular bristles present 4
   Spiracular bristles absent 6
4. Proboscis slender, flexible, as long as the whole body; one pro-epimeral bristle (or none); no sternopleural bristles.. .. .. *Rachionotomyia.*
   Proboscis otherwise; sternopleural bristles present 5
5. Proboscis rigid, hooked; no pro-epimeral bristles; cell R_2 extremely short; a V-shaped thickening of the wing-membrane between veins Cu_1 and Cu_2 (forks of 5th) .. .. *Megarhinus.*
   Proboscis flexible, straight in repose; several pro-epimeral bristles; cell R_2 long; no V-shaped thickening of wing-membrane.. .. *Theobaldia.*
6. Two pro-epimeral bristles .. .. *Orthopodomyia.*
   Several (about 5) pro-epimeral bristles 7
7. No post-spiracular bristles; female claws simple *Taeniorhynchus* (subgenus *Coquillettidia*).
   At least a few small post-spiracular bristles present; female claws nearly always toothed 8
8. Proboscis not very stout, straight or curved upwards in repose.. *Aëdes.*
   Proboscis stout, apparently (from dry specimens) curved downwards in repose .. .. *Armigeres.*
9. Lower mesepimeral bristles numerous.. .. .. *Lutzia.*
   Normally one lower mesepimeral bristle; often none, but very rarely two or three .. .. *Culex.*

Larvae.

1. Anal brush and barred area absent; thorax with a strong spine at each posterior corner .. .. *Rachionotomyia.*
   Anal brush and barred area present (except in first stage) 2
2. Siphon with one pair of ventral tufts 3
   Siphon with several ventral tufts 9
3. Siphonal tuft at or near base 4
   Siphonal tuft near middle, or beyond 5
4. Mouth-parts modified for predacity; a chitinous plate on each side of eighth segment; body colour dark reddish .. .. *Megarhinus.*
   Mouth-parts not modified for predacity; a patch of scales on each side of eighth segment; body colour not reddish .. .. *Theobaldia.*
5. Pecten teeth rounded and fringed apically; a chitinous plate on each side of eighth segment (in fourth stage only) in addition to the comb *Uranotaenia.*
   Pecten teeth (when present) sharply pointed, with denticles on one side; eighth segment with comb or patch of scales 6
6. Valves of siphon and tracheal system highly modified for subaquatic respiration .. .. *Taeniorhynchus.*
   Valves of siphon and tracheal system not specially modified 7
7. Extremely long single hairs on thorax and abdomen, besides long hair tufts; dorsal chitinous plates on segments 6–8 in the fourth stage; colour reddish .. .. *Orthopodomyia.*
   Single hairs not longer than the moderate tufts; no dorsal chitinous plates on segments 6 8; colour not reddish 8
8. Pecten present .. .. *Aëdes.*
   Pecten absent .. .. *Armigeres.*
9. Mouth-parts modified for predacity; anal segment long and pointed *Lutzia.*
   Mouth-parts not modified; anal segment shorter and less pointed.. *Culex.*

Genus **Uranotaenia,** Arrib.

Most writers have distinguished this genus mainly by the short upper fork-cell (cell R_2), but while this is a sufficient distinction in the majority of cases, there are a few species (*e.g., U. unguiculata*) in which the shortening of this cell is not very noticeable, and, on the other hand, some species of the *Aëdes* group have the cell so short that they have been mistaken for species of *Uranotaenia*. A more absolutely diagnostic character, though requiring a high magnification for its detection, is the absence in all known species of the genus of microtrichia on the wing-membrane. This distinguishes *Uranotaenia* sharply from all other Culicidae. The short anal vein, ending below or before the base of the radial sector, is shown also by the tropical genera *Hodgesia* and *Harpagomyia*. In all known species except *U. unguiculata* the front claws of the male are small and equal in length. The pleural bristles are very much reduced in number, there being only one or two in each of the pronotal, pro-epimeral, spiracular and pre-alar series.

The larva is not very sharply distinguished from that of *Aëdes*, except in the fourth stage, when the characteristic lateral chitinous plates appear on the eighth abdominal segment. The spine-like frontal hairs found in many species are represented by normal simple hairs in others (*e.g., U. unguiculata*). The form of the pecten-teeth is characteristic. The resting position in the water is almost horizontal.

The genus is tropicopolitan, but two species occur within the limits of the Palaearctic region.

1. **U. unguiculata,** Edw.

Uranotaenia unguiculata, Edwards, J. Proc. Asiatic. (Soc.) Bengal, ix, p. 51 (1913).

A line of pale blue flat scales passes round the margin of the mesonotum from wing-base to neck. The front claws of the male are unequal, the larger one with a small tooth.

The larva has been described by Joyeux.

Distribution.—Eastern Mediterranean region. Originally described from North Palestine, it has since been found in Jerusalem (*Goldberg*), Egypt (*Gough*), Macedonia (*Waterston, Joyeux*), and Italy (*Hargreaves*), but is always rare.

2. **U. bimaculata,** Leicester.

Uranotaenia bimaculata, Leicester, Cul. of Malaya, p. 226 (1908).

There is no line of flat scales on the margin of the mesonotum, but just in front of each wing-base is a large oval velvet-black spot on the integument. The front claws of the male are normal for the genus, small, equal and simple.

The larva is not yet described.

Distribution.—Japan (Tokio, *S. Yamada*); Malay Peninsula (*Leicester*). There is also a representative species (*U. mashonaensis,* Theo., = *U. bimaculata,* Theo.) in tropical Africa, which scarcely differs from the Oriental form. Should the two be united, the species must be known as *U. mashonaensis,* Theo.

Genus **Rachionotomyia** (Theo.) Edw.

This genus has never been fully described. I would define it as follows:—

Proboscis slender throughout; longer than the long front femora, and as long as the whole body. Mouth-parts normal; maxillary teeth very small. Palpi short in both sexes, not more than one-sixth as long as the proboscis. Female antennae slender, the verticils about four times as long as the joints; male antennae with shorter joints (except the last two) and longer verticils. Eyes practically touching above the antennae, the supra-antennal portion broad. A pair of strong bristles, placed close together, projecting forwards from immediately above the line of contact of the eyes; far away from these bristles are two other smaller ones on each side of the head. Prothoracic lobes well separated. Mesonotum with or without well-developed dorso-central bristles. One pro-epimeral bristle (even this is absent in some species). Several (3–6) spiracular bristles. No postspiracular bristles; no row of bristles on the upper part of the sternopleura; no lower meso-epimeral bristles. Sub-alar knob small, with few bristles. Postnotum bare, with a pair of slight furrows dividing it into three portions. Last segment of female abdomen blunt, very bristly. Male hypopygium: Lobes of ninth tergite elongate, with long apical bristles; side-pieces rather short, with conical, bristly claspette lobes; clasper long, terminal, with small thick terminal claw; tenth sternites split apically into several short, tergally projecting teeth, in a longitudinal row; aedoeagus very small, a simple, incomplete tube, with small parameres and sometimes apparently with some internal spines. Hind tibiae somewhat shorter than the others. Female claws simple; front claws of male unequal. Pulvilli absent. Wing-membrane with distinct microtrichia. R_s somewhat longer than $R_{2\,\&\,3}$; fork-cells moderately long; anal vein reaching well beyond the level of the base of R_s.

Larva (description based on a comparison of three Oriental species): Antennae short, smooth, apparently without hair on shaft. Clypeal hairs very small, simple. Posterior corners of metathorax with a long strong spine situated on a chitinous plate, without any accompanying long hairs; a similar but smaller spine towards each side of the mesothorax. First seven abdominal segments with seven pairs of strong stellate tufts (three dorsal, two lateral, two ventral). Thorax and first six

abdominal segments with long, lateral plumose hairs. Comb of eighth segment a row of stout spines, sometimes attached to a plate. Anal plate bears a comb of a few short spines. Siphon moderate, with sparse latero-ventral pecten and numerous hair-tufts or single hairs. Pupal paddles small, somewhat pointed, without fringe or terminal hair. Habitat: pitcher plants, bamboos, etc.

The genus is characteristic of the Oriental and Australasian regions, one species occurring in Japan.

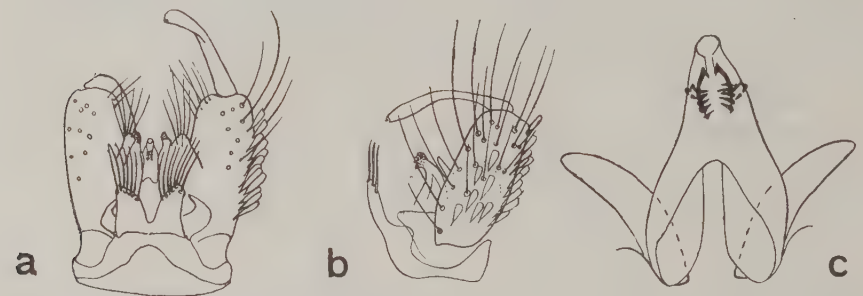

Fig. 4. Male hypopygium of *Rachionotomyia bambusa*, Yam.: *a*, ventral view, x75; *b*, lateral view, x75; *c*, aedoeagus, ventral view, x225.

Rachionotomyia bambusa, Yamada (fig. 4).

Rachionotomyia bambusa, Yamada, Dobutz. Z. Tokio, xxix, pp. 61–72 (1917).

This belongs to the rather numerous group of species with metallic silvery markings on the pleura and abdomen, and silvery spots on the femora. The chief diagnostic characters are as follows:—Head with a broad blue band in front. Prothoracic lobes with black scales. Pro-epimera with a few narrow black scales and one bristle. Mesonotum almost entirely dark brown, with long, straight, very narrow greenish-black scales. Scutellar scales broad, greenish black. Integument of pleurae mainly dark brown. Larger claw of front legs of male thick, with a pointed swelling, scarcely a tooth, beyond the middle. Lobes of ninth tergite of male each with about nine long, rather stout bristles.

I have not seen Yamada's description of the larva, and have had no specimens for examination.

Distribution.—Japan (Tokio, *S. Yamada*; Kofou, *L. Drouard de Lezey*).

Genus **Megarhinus,** R.D.

I now feel strongly inclined to accept the view of Howard, Dyar and Knab that *Toxorhynchites* should not be separated from *Megarhinus*, except as a rather weakly-marked subgenus. There are no important structural differences whatever, *Toxorhynchites* differing only in the shorter female palpi.

As Banks has pointed out, the labium in this genus is a rigid organ, and the structure of its apical part is apparently such as to prevent the possibility of the mouth-parts being used for sucking blood.

The pleural bristles in this genus are remarkable; there appear to be no true pro-epimeral bristles, but, on the other hand, a row of strong spiracular bristles is developed; there are no post-spiracular bristles, and the only bristles on the prothoracic lobes are a few which point forwards or downwards. There are only two pairs of ocular bristles instead of the usual row. The reduction of the mesonotal bristles has been remarked on by previous writers.

The presence of spiracular bristles, the close similarity in the male hypopygium, and the basally situated siphon-tuft of the larva, are points which seem to indicate some connection, distant no doubt, with *Theobaldia*, a connection which would not be suspected on a superficial examination.

The species of this genus often have very specialised habits, and these have a restricted distribution. Two species have already been recorded from the Palaearctic region; what is probably a third exists in south-east Europe.

1. **Megarhinus christophi,** Portch.

Megarhinus christophi, Portchinsky, Horae Soc. Ent. Ross. xviii, p. 122 (1884).

I do not know this species. According to Portchinsky's description it differs from *M. towadensis* in having silvery transverse bands on each of the first six abdominal segments and yellow lateral hairs on the sixth segment.

Distribution.—Amur (*Portchinsky*).

2. **Megarhinus towadensis,** Mats.

Megarhina towadensis, Matsumura, Thousand Insects of Japan, Add, ii, p. 445 (1916).

This is very much like the common Oriental *M. regius* (Tennent), but there are differences, evidently of specific value. The only specimen I have seen is one sent for determination from the Paris Museum by M. Séguy. This agrees with Matsumura's description, except that the narrow white ring on the first joint of the middle tarsus is close to but not at the base (the front legs are missing). The thorax is much rubbed, but the remaining mesonotal scales are metallic emerald green, quite unlike the dull scales of *M. regius*. The abdominal tuft is large and conspicuous, the long hair on the sixth and seventh segments black, on the eighth segment orange. The venter is mainly shining blue, but there are lateral yellow patches on sternites two, three and six, and sublateral, elongate yellow triangles on sternites four and five.

Distribution.—Japan (Towada, *Matsumura*; Kofou, *L. Drouart de Lezey*, 1906).

3. **Megarhinus** sp.

It is necessary to mention here a *Megarhinus* larva which was obtained near Karasouli, Macedonia, by Capt. Waterston.

The specimen was taken with a number of other larvae of different insects which were thought to be preying on mosquito larvae. It was not identified until after the collector's return to England, and no attempt was made at the time to rear it or to obtain others. It differs only in minute characters from the larvae of the African *M. brevipalpis*, the Oriental *M. regius*, and the North American *M. rutilus*, and it is therefore impossible to say whether it belongs to one of these species, or to some other, perhaps undescribed, form.

Genus **Theobaldia,** Neveu-Lemaire.

The two characters on which most writers have based their conception of this genus—the spotted wings and the position of the cross-veins in a straight line or nearly so—are both worthless for purposes of definition. In *T. longiareolata* and in the subgenus *Culicella* the cross-veins are well separated; while, on the other hand, in *Lutzia vorax* and occasionally in some other species (*e.g.*, *Culex tipuliformis*, *Aëdes rusticus*) they are practically in a straight line. The female palpal character on which Neveu-Lemaire founded the genus is of even less value. In one point, however, the adults do seem to be sharply distinguished from most other genera of the tribe CULICINI. This is in the possession, immediately in front of the prothoracic

spiracle, of a row of yellow bristles.* These bristles are quite apart from the usual pro-epimeral bristles, which are present in *Theobaldia* but somewhat reduced in length, their place being largely taken by the spiracular bristles, which are placed in a close-set row on the posterior side of the posterior ridge of the pro-epimeron. As in *Orthopodomyia*, there are no post-spiracular bristles.

The African species, *Leptosomatomyia fraseri*, shows the same pleural and hypopygial characters as *Theobaldia*, and should probably be included here. Apart from this, the genus is practically confined to the temperate regions of the northern hemisphere, three species occurring in the Punjab.

The larvae are sharply distinguished from others in the Palaearctic fauna (except *Megarhinus*) by the basally situated hair-tuft on the siphon.

Three subgenera (*Theobaldia*, *Culicella* and *Allotheobaldia*) are sharply defined by larval structure, but the distinction in the adults is not so clear, and it will therefore be best to tabulate all the species together, while admitting the subgenera as valid. I agree with Brolemann that *Culicella* is not generically separable from *Theobaldia*.

Adults.

1. Thorax with rather sharply defined white lines; femora and tibiae striped and spotted; costa largely pale-scaled; male palpi shorter than the proboscis (subgenus *Allotheobaldia*) .. .. *longiareolata*, Macq.
   Thorax without sharply defined white lines; femora and tibiae not striped; costa all dark; male palpi longer than the proboscis .. 2
2. Cross-veins in a straight line, or nearly (subgenus *Theobaldia*) 3
   Cross-veins well separated; tarsi with narrow pale rings embracing both ends of joints; wings not distinctly spotted (subgenus *Culicella*) .. 6
3. Tarsi entirely dark; wings not distinctly spotted .. *glaphyroptera*, Schin.
   Tarsi broadly ringed with white at the bases of the joints; wings more distinctly spotted (at least in the female) by accumulation of scales at the bases of the fork-cells and on the cross-veins 4
4. Femora without pale pre-apical ring; hind metatarsi without white ring in the middle .. .. *alaskaensis*, Ludlow.
   Femora with pale pre-apical ring; hind metatarsi with white ring in middle 5
5. Wing-spots distinct; abdomen conspicuously banded with black and white .. .. *annulata*, Schrank.
   Wing-spots indistinct, especially in the male; abdominal scales nearly all ochreous .. .. *subochrea*, Edw.
6. First joint of front tarsi of male longer than the remaining joints together; proboscis of female almost entirely black .. *morsitans*, Theo.
   First joint of front tarsi of male not longer than the remaining joints together; proboscis of female with many pale scales at the sides and beneath .. .. *fumipennis*, Steph.

Male Hypopygia.

1. Ninth tergite with a pair of long processes; aedoeagus remarkably large and complicated .. .. *longiareolata*, Macq.
   Ninth tergite without distinct processes; aedoeagus normal 2
2. Clasper somewhat swollen at the tip; side-piece with a subapical projection bearing a number of long, flattened appendages .. *glaphyroptera*, Schin.
   Clasper not swollen at the tip; side-piece otherwise 3
3. Side-piece with a more or less distinct, hairy subapical knob 4
   Side-piece without subapical knob or agglomeration of hairs 5

* This character is also possessed by *Megarhinus*, *Psorophora* and some Sabethine genera (*e.g.*, *Rachionotomyia*), but none of these could well be confused with *Theobaldia*.

4. Tip of eighth sternite with a close-set row of short spines *alaskaensis*, Ludlow.
   These spines absent .. .. .. *annulata*, Schrank. ; *subochrea*, Edw.
5. Side-pieces barely three times as long as their basal width ; tip of eighth sternite without row of spines .. .. *morsitans*, Theo.
   Side-pieces four times as long as their basal width ; tip of eighth sternite with row of short spines .. .. *fumipennis*, Steph.

Larvae.

1. Antennae short, with small hair-tuft or a single hair ; siphon short, at most three times as long as broad 2
   Antennae long, with large, many-branched tuft ; siphon long, at least five times as long as broad (subgenus *Culicella*) 3
2. Siphon with 6–10 stout, widely-spaced spines (subgenus *Allotheobaldia*) *longiareolata*, Macq.
   Siphon with a well-marked pecten, most of the teeth of which have their tips drawn out into long hairs (subgenus *Theobaldia*) *annulata*, Schrank ; *subochrea*, Edw.
3. Pecten straighter ; siphon without accessory spines .. *morsitans*, Theo.
   Pecten oblique ; siphon also with accessory spines .. ..*fumipennis*, Steph.

The larvae of *T. glaphyroptera* and *T. alaskaensis* are unknown.

Subgenus **Allotheobaldia,** Brolemann.

1. **Theobaldia** (**Allotheobaldia**) **longiareolata** (Macquart).

Culex longiareolatus, Macquart, Dipt. Exot. i, 1, p. 34 (1838).
Culex spathipalpis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Culex serratipes, Becker, Mitt. Zool. Mus. Berlin, iv, p. 78 (1908).
Culex annulatus var. *marocanus*, d'Anfreville, Bull. Soc. Path. Exot. ix, p. 140 (1916).

A very distinct species, which could not be confused with any other, either in the adult or larval state. The larva has been fully described by Langeron.

Distribution.—Throughout the Mediterranean region and in most of the Atlantic islands ; spreading southwards by East Africa as far as the Cape Province, and eastwards through Transcaspia, Mesopotamia and Persia to the Punjab. In France it has been taken as far north as Rambouillet (*Villeneuve*), but it appears to be otherwise unknown in central and northern Europe. Some new records are : Transcaspia (Askhabad, Firudza, Vrefskaja, *Ahnger*) ; Seistan (*Annandale*).

Subgenus **Theobaldia,** Neveu-Lemaire.

2. **Theobaldia** (**Theobaldia**) **glaphyroptera** (Schiner).

Culex glaphyropterus, Schiner, Fauna Austriaca, ii, p. 628 (1864).
Theobaldia bergrothi, Edwards, Entom. Tidskr. p. 50 (1921).

This was described by Schiner and Ficalbi as having spotted wings, and assuming that these authors' statements indicated a definite spotting such as that of *T. annulata*, I was led to regard the specimens sent me by Drs. Bergroth and Frey as a distinct new species. Later, however, I received a series of specimens from the Vienna Museum, including some of Schiner's original series, and these showed that the spotting of the wings is really hardly distinguishable, except for a darkened area of the membrane towards the costa in the middle. The Finnish and Swedish female specimens for which I proposed the name *bergrothi* are almost certainly only *T. glaphyroptera*. On the other hand, Theobald's *Pseudotheobaldia niveitaeniata*, which I supposed in 1913 to be synonymous with *T. glaphyroptera*, is a perfectly distinct species.

T. glaphyroptera is distinct in coloration from all other European species, but is very similar to the North American *T. impatiens*, Walk., from which it differs by the very distinctive male hypopygium. The male palpi are much more slender than those of any other European species, and seem to indicate an approach to *Culex*, although the terminal joints are not upturned. The ornamentation of the thorax is variable, some specimens having a distinct pattern of ochreous or whitish lines (one straight median, and a pair of curved lateral) on a dark ground.

The larva is unknown.

Distribution.—Recorded by Schiner from Austria, and by Eckstein from the Strasburg district. The specimens I have seen are from Austria (Rekawinkel, *Pokorny ;* Hammern, *Mik ;* also several from Schiner's original series, collected by Egger) ; Moravia (Frain, *Handlirsch*) ; Hungary (Bartfa, *Kertész*) ; Sweden (Stockholm ; Dalecarlia, Norrbotten, *Boheman ;* Östergötland, *Haglund*) ; Germany(?) (Coll. Loew, Berlin Museum) ; Finland (Kivikoski, Saima-Canal, *Adelung ;* Kuustö, *Lundström ;* Kittilä, *Krogerus ;* Petrosaw, *Günther ;* Säräsniemi, *Wuorentaus*).

3. **Theobaldia (Theobaldia) alaskaensis,** Ludlow.

Theobaldia alaskaensis, Ludlow, Can. Ent. xxxviii, p. 326 (1906).
Culiseta siberiensis, Ludlow, Insec. Inscit. vii, p. 151 (7th Jan. 1920).
Theobaldia arctica, Edwards, Bull. Ent. Res. x, p. 136 (end Jan. 1920).

In describing *T. arctica* I compared it with *T. alaskaensis*, and suggested that the two might be the same, though according to the published figure of *T. alaskaensis* there appeared to be certain differences in the male hypopygium. Recently Dr. H. G. Dyar sent me a male from Alaska which shows that the supposed differences do not exist. The species is easily distinguished by leg markings from the other European forms, but is represented by allied species, differing in hypopygial structure, in Mexico and the Punjab.

Distribution.—I have examined specimens from Archangel ; Scotland ; N. England ; Sweden (Norrbotten, *Boheman ;* Jemtland, *Schönherr ;* Stockholm, *Boheman*) ; Lower Austria ; Upper Silesia (Astron, *Brauer*) ; Siberia (Irkutsk, *Ahnger ;* Inserovo, 62° 5′, *Trybom*). Ludlow and Dyar record it from Eastern Siberia, Alaska and Alberta.

4. **Theobaldia (Theobaldia) annulata** (Schrank) (fig. 1A).

Culex annulatus, Schrank, Beitr. Z. Naturg. p. 97 (1776).
? *Culex variegatus,* Schrank, Enum. Ins. Austr. p. 482 (1781).
? *Culex annulatus,* de Fourcroy, Ent. Paris, p. 516 (1785).
Culex annulatus, Fabricius, Mantissa Ins. ii, p. 363 (1787).
? *Culex nicaensis,* Leach, Zool. Journ. ii, p. 292 (1825).
Culex affinis, Stephens, Zool. Journ. iv, (1825).

A common and easily recognised domestic species, normally exhibiting very little variation except in size. North European specimens are on the average larger than those from the south.

The name *Culex annulatus* was apparently proposed independently by Schrank, de Fourcroy and Fabricius, but the same species was designated in each case. De Fourcroy's diagnosis is totally inadequate, but he gives the habitat as Parisian gardens, so that he more probably had this species than an *Aëdes*.

C. variegatus, Schrank, is generally quoted as a synonym of *T. annulata,* but the inadequate diagnosis would perhaps serve better for *Aëdes lutescens*. Walker mentions specimens of *T. annulata* in the British Museum "from Dr. Leach's collection," and it is possible that these specimens (which are no longer in existence) may have been the originals of *C. nicaensis*.

The larva has been described by Langeron.

Distribution.—Throughout Europe, but probably commoner in the north than in the south, where it seems to be largely replaced by *T. longiareolata*; extending into Palestine (Jerusalem, *Dr. Goldberg*) and North Africa (Biskra, Algeria, *Eversmann*; etc.). Has not yet been found further east, but is represented in the United States by an allied species. A female in the Berlin Museum is labelled "Ural, *Eversmann*."

5. **Theobaldia (Theobaldia) subochrea,** Edw.

Theobaldia annulata var. *subochrea*, Edwards in Wesenberg-Lund, Danske Vid. Selsk. Skr., Nat. Math. Afd. (8) vii, p. 198 (1921).

Theobaldia subochrea, Edwards, Ent. Tidsk. p. 50 (1921).

? *Culex penetrans*, Robineau-Desvoidy, Mem. Soc. Hist. Nat. Paris, iii, p. 407 (1828).

Though structurally identical with *T. annulata*, this differs so conspicuously and sharply in coloration that it must be regarded as a distinct species, especially as it is not confined (as was at first thought) to desert areas, and its coloration therefore cannot be purely adaptive. The differences from *T. annulata* are as follows:—

Mesonotum with the integument lighter, the scales almost uniformly reddish brown. Abdomen almost uniformly ochreous, the dark brown scales of *T. annulata* being replaced by light ochreous brown, and the white ones by almost the same colour. Whitish lateral patches, however, remain at the base of each segment, and the basal segmental bands, as well as the median line of the second segment, can be faintly made out on account of their slightly lighter colour. Leg-markings as in *T. annulata*, but somewhat less conspicuous owing to the dark parts being somewhat lighter. Wing-spots very faint, the scales being less densely aggregated than in *T. annulata*; in the male the spotting of the wing is scarcely perceptible at all.

The larva, so far as I can see, is absolutely identical with that of *T. annulata*.

Robineau-Desvoidy's description of *C. penetrans* applies in many respects to this species, but he states that the third joint of the middle tarsi of the male is bristly, which if true, is very remarkable. The type being lost, *C. penetrans* may be left as a possible synonym of *T. subochrea*.

Distribution.—I have examined specimens from the following places:—Mesopotamia (Basra, *Capt. P. J. Barraud*; a series including the type male); Persia (Ghilan, 950 m., Calhors, *J. de Morgan*); Palestine (Jerusalem, *Dr. Goldberg*); Macedonia (Hadji Geul, *Capt. J. Waterston*); Denmark (brackish-water swamp near Copenhagen, *Dr. C. Wesenberg-Lund*); England (Earl's Court, London, *W. J. Pendlebury*). In Mesopotamia this was the only form found; in the other countries *T. annulata* was found in the same localities.

Subgenus **Culicella,** Felt.

6. **Theobaldia (Culicella) morsitans** (Theobald).

Culex morsitans, Theobald, Mon. Cul. ii, p. 8 (1901).

? *Culex flavirostris*, Meigen, Syst. Beschr. vi, p. 242 (1830).

Apart from the characters mentioned in the key, this species can generally be distinguished from *T. fumipennis* by its slightly smaller size, by the more slender and rather less hairy male palpi, and by the absence of distinct Λ-shaped black marks on the abdominal sternites in both sexes. I at one time considered that the North American *T. dyari* (Coq.) might be synonymous, but Dr. H. G. Dyar informs me that the two are distinct by hypopygial characters.

Meigen's statements concerning the proboscis and palpi of his *C. flavirostris* (male) might possibly be taken as indicating this species, but he says "Füsse ganz braun," which presumably excludes it. Like the great majority of Meigen's names, *C. flavirostris* is unrecognisable.

The larva varies in colour, but is usually dark brown or blackish.

Distribution.—Throughout Europe, from Britain and France to Finland (Sammatti, *Sahlberg*; Kuustö, *Lundström*), Petrograd (♂ in coll. *B. Lichtwardt*) and Macedonia. Not yet known from North Africa or Asia.

7. **Theobaldia** (**Culicella**) **fumipennis** (Steph.) (fig. 5c).

Culex fumipennis, Stephens, Zool. Journ. i, p. 453 (1825).
Culex ficalbii, Noé, Bull. Soc. Ent. Ital. xxxi, p. 238 (1899).
Culicada theobaldi, de Meijere, Tijd. v. Ent. liv, p. 142 (1911).

Distinguished by the characters mentioned in the keys and under *T. morsitans*.

The larva, apart from the conspicuous structural differences in the siphon, may generally (perhaps always) be distinguished in life from that of *T. morsitans* by its pale yellowish green colour. Both species are mainly bottom feeders and are generally found in shallow, weedy, stagnant water.

Distribution.—Throughout Europe, except perhaps in the far north. The material I have examined shows a range from Scotland and France to Sweden and Macedonia.

Genus **Orthopodomyia**, Theo.

This genus is well characterised in the larval state by the absence of a pecten on the siphon and the development, in the fourth-stage larva, of dorsal chitinous plates on the sixth, seventh and eighth segments of the abdomen. These two characters together will distinguish the genus from all other mosquitos. In addition there are some small peculiarities, such as the development of reddish pigment in the body of the larva, and the very long single lateral hairs on the thorax and abdomen. The adult characters are not very well marked, the most obvious being: (1) the presence of only two pro-epimeral bristles; (2) the small number of bristles on the pre-alar prominence of the pleurae; there are five or six in *O. pulchripalpis*, but the number is reduced to one or none in the tropical species, while in *Culex*, *Aëdes*, *Theobaldia* and *Taeniorhynchus* there are 12 or more; (3) the length of the first front tarsal joint, which in both sexes is distinctly longer than the remaining four together, while in most other mosquitos it is only about as long; (4) the rather long and stout antennae of the male, all the joints being longer than usual; (5) the short fourth joint of the front and middle tarsi of the female, which is much shorter than the fifth, and like that of the male, scarcely any longer than broad. The very long fork-cells and the long first hind tarsal joint are also noticeable. The hypopygial structure is practically the same as in *Theobaldia* (subgenus *Culicella*).

1. **Orthopodomyia pulchripalpis** (Rondani).

Culex pulchripalpis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Orthopodomyia albionensis, MacGregor, Journ. R.A.M.C. p. 451 (1919).

The beautiful pattern of narrow, pure white lines on the deep black thorax is not to be seen in any other species known from the Palaearctic region, though confusion might be possible with some Himalayan species of *Aëdes*, such as *A. pseudotaeniatus*. The entirely white terminal joint of the male palpi, and the rather long female palpi (nearly half as long as the proboscis), will distinguish it from all such species, without reference to the generic characters. The North American *O. signifer* (Coq.) is very closely allied, being structurally identical, but differing in having scattered white scales on the wings, especially a patch of white scales in the middle of the wing over the cross-veins. The Oriental species are very differently coloured.

In Ficalbi's redescription of Rondani's types he does not definitely describe the thorax, but refers to the mesonotal scales as "giallo-ottono?" I therefore at first considered that the British and Italian forms could not be the same. However,

Prof. M. Bezzi has kindly re-examined for me Rondani's types in the Florence Museum, and reports that though the thorax in both specimens is much damaged by the pin, it is black, "even deep black," and there are traces of white lines, and two white spots in the middle of the scutellum. There can therefore be little or no doubt of the identity of *C. pulchripalpis* and *O. albionensis*.

The larva lives in tree-holes, and shows the modifications commonly found in such a habitat. It has been described by MacGregor and Lang.

Distribution.—Italy; England (Epping Forest); France (near Paris, *Séguy*). The species may not be so rare as is supposed, since all the specimens so far known (with the probable exception of Rondani's types) have been obtained by rearing.

Genus **Taeniorhynchus,** Arrib.

This genus may be distinguished in the adult from *Culex* by the absence of empodia; from *Theobaldia* by the absence of spiracular bristles; and from *Aëdes* by the absence of a definite "tibial scraper" (a close-set row of bristles at the tip), by the non-retractile eighth segment of the female abdomen and the structure of the male hypopygium. The wing-scales vary greatly in width in the different species, but are nearly always broader than in *Aëdes* or *Culex*. Although no more satisfactory distinctions can be discovered in the adults, the larval siphon is so wonderfully modified that on this character the genus is extremely well marked. At the same time the larval structure of *Mansoniodes* is so nearly identical with that of *Taeniorhynchus* and *Coquillettidia* that the three are much best regarded as subgenera under the main genus *Taeniorhynchus*, in spite of some rather conspicuous differences in the adults.

The only known Palaearctic species* belongs to the subgenus *Coquillettidia*, to which belong also the North American species and the rather numerous African and Oriental species placed by Theobald in *Chrysoconops*. *Coquillettidia* differs from the other subgenera in having no post-spiracular bristles, and this affords a further distinction from *Aëdes*, in which a few of the bristles are apparently always present.

Taeniorhynchus (**Coquillettidia**) **richiardii** (Fic.).

Culex richiardii, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 50 (1889), and xxxi, p. 199 (1899).

The rather broad wing-scales and the pale ring in the middle of the first joint of the hind tarsus will distinguish this species from other mosquitos in the European fauna.

The bionomics and morphology of the early stages have been described in detail by Wesenberg-Lund.

Distribution.—Apparently occurs somewhat locally throughout Europe, except probably in the far north, and extends into Palestine. Some apparently new records are: Sweden (Småland, Stockholm, *Boheman*); Hungary (Keszthely, *Kertész*); Austria (Freistadt, *Frauenfeld*).

Genus **Aëdes,** Mg.

This genus, as a whole, is characterised as follows:—Proboscis of uniform thickness throughout. Palpi of the female less than one-quarter as long as the proboscis. Antennae distinctly plumose in the male, with the last two joints elongate; with moderately long verticils in the female, all the flagellar joints being about equal in length. Eyes distinctly separated. A continuous row of orbital bristles. Pronotal lobes widely separated. Pro-epimeral bristles about

* The South American *T. titillans* has been recorded from Rumania by Leon, but no doubt incorrectly.

4–6, in a posterior row overlapping the spiracle. Spiracular bristles absent. Post-spiracular, pre-alar, sternopleural and upper mesepimeral bristles all present and generally numerous. Postnotum without setae. Eighth segment of female abdomen retractile, a wide membrane between it and the seventh. Side-pieces of male hypopygium with a lacuna of chitinisation extending the whole length of the inner side; claspers articulating in an horizontal plane. Tenth segment with tergites feebly developed; sternites simple, without teeth or spines. Hind tibiae with the usual row of fine microscopic hairs just before the tip on the inner side, and also with a row of 7–10 longer hairs parallel with the first row and slightly more distally placed. First hind tarsal joint shorter than the tibia. Pulvilli absent. Front and middle claws of female nearly always toothed. Cell R_2 (upper fork-cell) seldom much longer than its stem. Vein A_n (sixth longitudinal) terminating distinctly beyond the level of the base of R_s (second vein). Distinct microtrichia on wing-membrane.

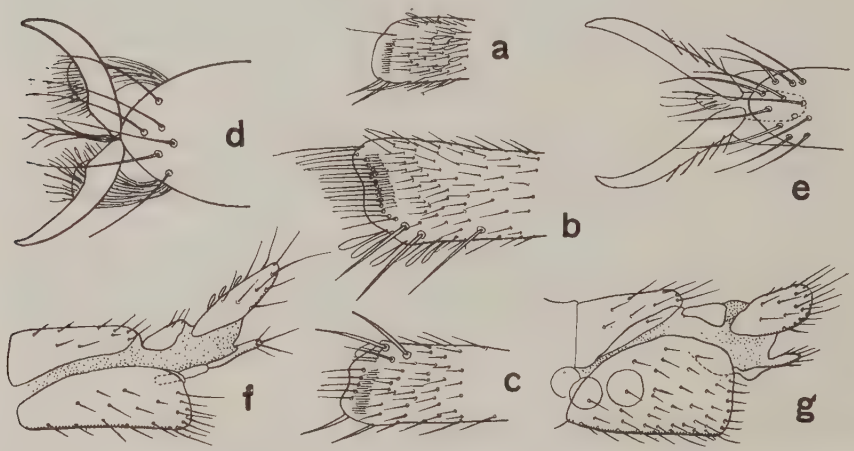

Fig. 5. Structural details of Culicidae: a, tip of hind tibia, seen from the inner side, of *Culex hortensis* (scales omitted), ×65; b, the same structure in *Aëdes lepidonotus*; c, the same in *Theobaldia fumipennis*; d, tip of last tarsal joint of *Lutzia vorax*, showing claws, empodium and pulvilli, ×340; e, tip of last tarsal joint of *Theobaldia annulata*, showing claws, small empodium, and absence of pulvilli, ×340; f, tip of abdomen of *Aëdes lepidonotus* ♀, showing slender eighth segment with narrow sternite, ×40; g, the same, *Aëdes geniculatus* ♀, showing stouter eighth segment with broader sternite.

Larva.—Mouth-parts not specially modified for predaceous habits, but the inner hairs of the mouth-brushes are generally more or less serrate. Antennal tuft generally at or before the middle. Abdomen without chitinous plates except for the anal saddle, and sometimes small plates at the bases of the thoracic hairs. Eighth segment with a lateral comb or patch of scales. Siphon unmodified, short and stout, at most four times as long as its breadth at the base, provided with a well-developed pecten and a single pair of ventral hair-tufts, situated about or beyond the middle; only very exceptionally with accessory dorsal hairs or hair-tufts.

As pointed out by Dyar (Insecutor Inscitiae, vi, p. 71, 1918) the genus can be divided into two main groups, on the presence or absence of distinct claspettes in the male hypopygium (the term claspette in this connection signifying a definite structure separated from the base of the upper flap of the side-piece, and terminating in a flattened appendage or a more or less modified bristle). Dyar's two groups may

also be defined on the structure of the mesosome of the aedoeagus. In the group which possesses claspettes the mesosome is a simple tube, rather lightly chitinised below and at the sides, membranous above. In the other group the mesosome is a paired structure, the halves of which are more or less crenulate, spiny or brush-like. Both these distinctions are so well marked that one would expect to find corresponding distinctions in the body characters or in the larvae, but all efforts in this direction have so far been fruitless.

The first group includes the subgenera *Ochlerotatus* and *Finlaya*, and is spoken of by Dyar as the New World type—inappropriately, since it includes the majority of the European mosquitos, and has many representatives in Australia, while *Finlaya* attains its strongest development in the Oriental region. The second or Old World group (subgenera *Ecculex*, *Aëdes* and *Stegomyia*) is almost confined to the tropical and subtropical regions of the Old World.

The subgenera occurring in the Palaearctic region may be separated (as adults) by the following keys, which will not necessarily hold good for the species of other regions.

Male Hypopygium.

1. Claspettes present; mesosome an unpaired simple structure 2
   Claspettes absent; mesosome a paired, more complicated structure .. 3
2. Side-piece with more or less distinct apical and basal lobes .. *Ochlerotatus.*
   Side-piece without apical or basal lobes .. .. *Finlaya.*
3. Clasper deeply divided, placed before tip of side-piece; without articulated spine .. .. *Aëdes.*
   Clasper not divided, placed at tip of side-piece, with distinct articulated spine 4
4. Spine of clasper well before the tip .. .. *Ecculex.*
   Spine of clasper at the tip (except in *A. vittatus*) .. .. .. *Stegomyia.*

Other Adult Structures.

1. Proboscis distinctly longer than front femora; last two joints of male palpi distinctly swollen, hairy, and turned downwards 2
   Proboscis not longer than front femora; male palpi otherwise; female cerci short 4
2. Female cerci short, the eighth sternite large and prominent in repose; male palpi somewhat shorter than the proboscis .. .. .. *Finlaya.*
   Female cerci long, the eighth sternite much smaller and not prominent in repose 3
3. Male palpi longer than the proboscis .. .. *Ochlerotatus.*
   Male palpi not longer than the proboscis .. .. *Ecculex.*
4. Palpi alike in the two sexes, very short; tarsi dark .. .. .. *Aëdes.*
   Male palpi long, slender, the last two joints upturned and nearly bare; tarsi with white rings at the bases of the joints .. .. .. *Stegomyia.*

The adults of these subgenera are treated separately, but it will be more convenient to tabulate all the known larvae together, as follows:—

Key to the known Larvae of Palaearctic Species of Aëdes *(sens. lat.).**

1. Antennal tuft represented by a single minute hair; shaft devoid of small spines; eighth abdominal segment with a well-marked comb of teeth set in a single row 2

* This key will not necessarily apply to any but fourth-stage larvae. For the characters of *A. dorsalis* and *A. intrudens* I have relied on American descriptions, and for those of *A. alpinus* on Wesenberg-Lund's description of specimens from Greenland.

Antennal tuft at least two-haired; shaft nearly always spinose; eighth abdominal segment with a patch of scales or teeth which may tend to form a single row when few in number 5

2. Antennae rather long; dorsal surface of abdomen with numerous stellate tufts (*Finlaya*) 3
Antennae short; dorsal surface of abdomen without conspicuous stellate tufts (*Stegomyia*) 4

3. Abdominal tufts composed of long, stout bristles .. .. *echinus*, Edw.
Abdominal tufts composed of shorter and much more slender bristles *geniculatus*, Oliv.

4. Comb-teeth simple .. .. *albopictus*, Skuse.
Comb-teeth with lateral basal denticles .. .. .. *argenteus*, Poiret.

5. Shaft of antenna quite bare, tuft 2–3-haired (*Stegomyia*) .. *vittatus*, Bigot.
Shaft of antenna spinose (very slightly so in *mariae*), tuft generally multiple 6

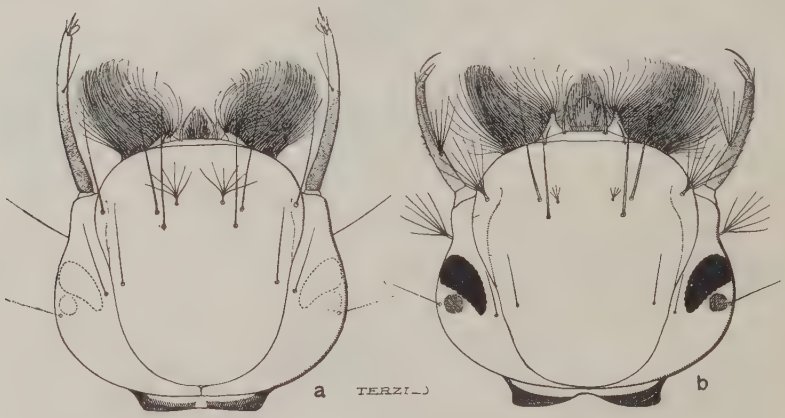

Fig. 6. Heads of larvae: a, *Aëdes echinus*, Edw.; b, *Aëdes mariae* (Serg.).

6. Pecten with detached, simple teeth outwardly; hair-tuft very small and well beyond middle of siphon; no long hairs near middle of front margin of thorax 7
Either the pecten has no detached simple teeth outwardly, or the hair-tuft is larger and situated practically at the middle of the siphon; long hair-tufts present near middle of front margin of thorax (*Ochlerotatus*) 8

7. The three post-antennal hairs (Lang) nearly in a straight line (*Aëdes*) *cinereus*, Mg.
Middle post-antennal hairs almost directly in front of the inner (*Ecculex*) *vexans*, Mg.

8. Siphon with three or four pairs of hairs on dorsal (anterior) surface *rusticus*, Rossi.
Siphon without hairs on dorsal surface 9

9. Antennae longer than the head .. .. .. *diantaeus*, H. D. & K.
Antennae shorter than the head 10

10. Siphonal index about 1·5 11
Siphonal index 2 or more; antennal spinules well-developed 12

11. Antennae almost devoid of spinules; pecten-teeth very long *mariae*, Serg.
Antennal spinules well-developed; pecten-teeth shorter .. *zammittii*, Theo.
12. Five or six small hair-tufts in anal brush before the barred area 13
At most three such tufts; siphonal index 3 or less 17
13. Siphonal index distinctly over 3; terminal teeth of pecten more or less detached 14
Siphonal index at most 3; all pecten-teeth close-set 16
14. Comb of eighth segment with 6–9 teeth in one irregular row *semicantans*, Mart.
Comb with 23–35 teeth in a triangular patch 15
15. Siphonal index about 3·2; anal gills half as long as the saddle *lutescens*, F.
Siphonal index quite 3·5; anal gills as long as the saddle .. *excrucians*, Walk.
16. Siphonal index 2·3–2·7 .. .. *annulipes*, Mg.
Siphonal index 2·6–3 .. .. *maculatus*, Mg.
17. One or two simple detached pecten-teeth beyond the siphonal tuft *cataphylla*, Dyar.
No pecten-teeth beyond the tuft 18
18. Anal gills much shorter than the saddle 19
Anal gills at least as long as the saddle 22
19. Hair-tuft distinctly beyond middle of siphon; anal gills, one-third to two-thirds as long as saddle .. .. *caspius*, Pall.
Hair-tuft practically at middle of siphon 20
20. Siphonal index 2; anal gills globular .. .. *detritus*, Hal.
Siphonal index 2·6–3 21
21. Anal gills globular, not a quarter as long as the saddle .. *dorsalis*, Mg.
Anal gills half as long as the saddle .. .. *salinellus*, Edw.
22. Comb with 50 or more scales in the patch 23
Comb with 10–20 pointed scales in the patch 24
23. Comb-scales sharp-pointed; anal gills twice as long as the saddle *pullatus*, Coq.
Comb-scales blunt-ended, fringed; anal gills about as long as the saddle *communis*, De G.
24. Last few pecten-teeth detached 25
All pecten-teeth close-set 26
25. Anal segment with a complete chitinous ring, only half as long as the gills; frontal hairs single .. .. *alpinus*, L.
Anal segment with saddle only, as long as the gills; frontal hairs branched .. .. *intrudens*, Dyar.
26. Anal segment with a complete chitinous ring, about as long as the gills *punctor*, Kirby.
Anal segment with an incomplete ring, only half as long as the gills *sticticus*, Mg.

Subgenus **Ochlerotatus**, Arrib.

Adults. Proboscis slender, distinctly longer than the front femora. Palpi short in the female; longer than the proboscis in the male (very rarely of equal length or slightly shorter), the last two joints and the tip of the long joint swollen and hairy, the last two joints turned very slightly downwards, the terminal joint generally a little more slender than the penultimate. Hair-whorls of male antennae rather irregular, the majority of the hairs projecting either dorsally or ventrally. Vertex with narrow scales only, the flat ones being confined to the sides of the head. Lower mesepimeral hairs usually (not always) present. Male hypopygium with long,

simple claspers which are provided with a terminal spine; side-pieces with well-developed basal lobes and more or less distinct apical lobes; distinct claspettes always present, terminating in a more or less flattened appendage; aedoeagus simple, the mesosome never divided into two halves. Female cerci always well-developed and long, the eighth segment small, rarely visible at all externally. All the claws of the female toothed (normally).

Larva. Antennae with a well marked hair-tuft and minute spicules on the surface. Frontal hairs generally simple or only slightly branched, the anterior pair immediately in front of the lower. Abdomen without well-marked stellate tufts; the scales of the comb of the eighth segment in a triangular patch.

This subgenus includes the great majority of the Palaearctic and Nearctic species of *Aëdes*, and attains its maximum development in the north temperate parts of these regions; it is almost or quite unrepresented in the Ethiopian and Oriental regions, but appears again with numerous representatives in southern Australia, and one or two in New Zealand. Many species also occur in the Neotropical region, and it is possible therefore that Australia was colonised by way of South America, especially as some of the South American, New Zealand and Australian species show rather marked affinities. We may perhaps assume from this that the subgenus is an old-established one.

The Palaearctic species are divisible (as adults) into three groups according to the markings of the tarsi. The first two of these groups appear to be natural assemblages of species, but the third, with dark tarsi, is less natural and shows more structural diversity. These groups may be known as the *dorsalis*-group, the *annulipes*-group and the *communis*-group; as mentioned below, *A. punctor*, though placed on account of coloration in the *communis*-group, shows signs of affinity with the *dorsalis*-group, while other members of the *communis*-group (such as *A. communis* itself) are probably more nearly related to the *annulipes*-group. The structure of the male hypopygium shows the isolated position of *A. rusticus* and *A. lepidonotus*, but suggests an affinity between *A. pullatus* and the peculiar *A. diantaeus*.

Adults.

1. Tarsi with pale rings embracing both ends of the joints, the last hind tarsal joint entirely pale (*dorsalis*-group) [compare also *Finlaya togoi*] .. 2
   Tarsi with pale rings at the bases of the joints only (*annulipes*-group) [compare also subgenera *Ecculex* and *Stegomyia*, and *Finlaya japonica*] 7
   Tarsi without pale rings (*communis*-group) [compare also subgenera *Aëdes* and *Finlaya*] 12
2. Abdomen with a pale median dorsal stripe in addition to transverse bands; sometimes entirely pale 3
   Abdomen with whitish bands at the bases of the segments only 4
3. Mesonotal scales generally fawn-coloured, with two narrow white bands running the whole length; dark and light wing-scales evenly mixed *caspius*, Pall.
   Mesonotal scales generally duller brown, with two broad, creamy bands in front; dark scales aggregated on certain veins .. .. *dorsalis*, Mg.
4. Wings and legs densely speckled with pale scales; tarsi brown with creamy rings 5
   Wings and legs only very slightly speckled; tarsi black with white rings.. 6
5. Mesonotal scales uniformly brown or fawn-coloured.. .. *mariae*, Serg.
   Mesonotum with two longitudinal bands of white scales .. *zammittii*, Theo.
6. Mesonotal scales bronzy ochreous, not forming distinct markings *pulchritarsis*, Rond.
   Mesonotum with whitish median stripe .. .. *pulchritarsis*, Rond., var.

7. Outer side of hind femora with numerous scattered dark scales; white rings of middle joints of hind tarsi less than half as long as the joints; thorax dark with some obscure paler markings .. .. *maculatus*, Mg.
Outer side of hind femora pale except towards the tip; white rings of middle joints of hind tarsi at least half as long as the joints 8

8. Costa at most with scattered pale scales; abdomen largely dark 9
Costa pale-scaled on anterior edge, at least on basal half; abdominal scales mainly or all yellow 11

9. Abdomen dark, tergites with well-defined basal white bands narrowed in the middle .. .. *semicantans*, Martini.
Abdomen with ill-defined yellowish bands and scattered yellowish scales.. 10

10. Mesonotum with a distinct broad median band of dark scales, sides yellowish; pale bands of abdomen mainly basal .. .. *annulipes*, Mg.
Mesonotum with obscure markings; pale bands of abdomen largely at apices of tergites .. .. *excrucians*, Wlk.

11. Costa yellow-scaled only on the basal half .. .. *freyi*, sp. n.
Costa mainly yellow-scaled in its entire length .. .. .. *lutescens*, F.

12. Pro-epimeral scales all flat and straight, the upper ones black .. .. *rusticus*, Rossi.
Pro-epimeral scales all ochreous, the upper ones narrow and curved .. 13

13. Postnotum with a tuft of scales .. .. *lepidonotus*, Edw.
Postnotum without scales 14

14. Wing-membrane whitish; costal scales all pale .. .. *albescens*, sp. n.
Wing-membrane not whitish; costal scales mostly or all dark 15

15. Front and middle femora conspicuously mottled in front with dark and light scales 16
Front and middle femora with only a few pale scales in front 19

16. Head and thorax with very dense bristles; integument deep black.. *alpinus*, L.
Head and thorax only moderately bristly; integument of legs paler .. 17

17. The dark parts of the abdominal tergites with scattered pale scales; male palpi usually all dark .. .. *detritus*, Hal.
The dark parts of the abdominal tergites without scattered pale scales; male palpi with a whitish ring or numerous pale scales on the long basal joint 18

18. Proboscis all dark .. .. *cataphylla*, Dyar.
Proboscis with numerous pale scales in the middle .. .. *salinellus*, Edw.

19. Hind femora pale, with a sharply defined black-scaled area at the tip *diantaeus*, H. D. & K.
Dark area at tip of hind femora much less sharply defined 20

20. Hind tibia (at least in the female) with a distinct whitish stripe on the outer side running nearly the whole length; mesonotum with white scales at the sides, blackish in the middle .. .. .. *sticticus*, Mg.
Hind tibia without whitish stripe on outer side in either sex 21

21. Scales of head and mesonotum ochreous brown, the mesonotum usually with one broad dark brown median stripe; sometimes with two ill-defined stripes, or none .. .. *punctor*, Kirby.
Scales of head and mesonotum darker brown, often mixed with white at the sides; the mesonotum usually without distinct stripes, or with two ill-defined ones 22

22. Flat scales of the head approaching the middle line .. .. *parvulus*, Edw.
Flat scales confined to the sides of the head .. .. .. *communis*, De G.; *intrudens*, Dyar; *pullatus*, Coq.

Male Hypopygia.

1. Basal lobe of side-piece bearing a row of flattened bristles or scales; terminal spine of clasper wavy .. .. *rusticus* (Rossi).
   Basal lobe of side-piece quite otherwise; terminal spine of clasper straight 2
2. Side-piece with three spines or differentiated bristles; two on the basal lobe, backwardly directed, one more distally placed and inwardly directed 3
   Side-piece with at most two differentiated bristles on the basal lobe .. 5
3. Side-piece swollen in the middle, where it has a large inwardly-directed hair-tuft .. .. *diantaeus*, H. D. & K.
   Side-piece more regularly shaped, without hair-tuft in the middle .. 4
4. A distinct hair-tuft adjoining the apical lobe; stem of claspette with a distinct projection near the middle.. .. .. .. *intrudens*, Dyar.
   No definite hair-tuft adjoining the apical lobe; stem of claspette somewhat angulated but without definite projection.. .. .. *pullatus* (Coq.).

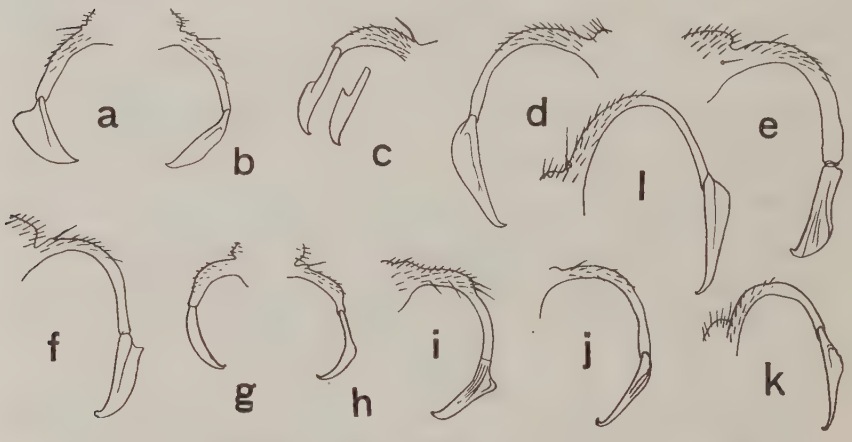

Fig. 7. Claspettes of Palaearctic species of *Aëdes*, dissected from hypopygia and drawn in side view, all × 75: a, *A. maculatus* (Mg.); b, *A. semicantans*, Mart.; c, *A. lutescens* (F.); d, *A. freyi*, sp. n.; e, *A. annulipes* (Mg.); f, *A. excrucians* (Walk.); g, *A. punctor* (Kirby); h, *A. detritus* (Hal.); i, *A. pullatus* (Coq.); j, *A. communis* (De G.); k, *A. salinellus*, Edw.; l, *A. cataphylla*, Dyar.

5. Basal and apical lobes of side-piece both very small, the latter hardly distinguishable 6
   Either basal or apical lobes, or both, quite large and conspicuous .. 8
6. Appendage of claspette short and twisted, rounded at tip *lepidonotus*, Edw.
   Appendage of claspette long, curved and pointed 7
7. Basal lobe without a spine .. .. *mariae* (Serg.); *zammittii* (Theo.).
   Basal lobe with a distinct spine .. .. .. *pulchritarsis* (Rond.).
8. Basal lobe with two spines; apical lobe ill-defined 9
   Basal lobe with at most one spine; apical lobe nearly always well-marked.. 10
9. Basal lobe very prominent (fig. 8 b) .. .. *dorsalis* (Mg.).
   Basal lobe much less prominent (fig. 8 a) .. .. .. *caspius* (Pall.).
10. Apical lobe reaching back to near middle of side-piece, and clothed with very short, curved bristles; stem of claspette short and straight .. 11
    Apical lobe not reaching so far back, and bearing longer bristles .. 12

11. Appendage of claspette three times as long as broad; basal lobe not separated from the side-piece .. .. *punctor* (Kirby).
Appendage of claspette not much longer than broad; basal lobe separated from the side-piece in its apical portion .. .. .. *sticticus* (Mg.).
12. Basal lobe with a strong black spine and short pubescence .. *lutescens* (F.).
Spine of basal lobe when present weaker and paler, and generally accompanied by long bristles 13
13. Basal lobe small, without spine, but a rugose area extends more than half the length of the side-piece 14
Basal lobe larger, spine generally well-marked, rugose area not nearly reaching middle of side-piece (except in *freyi*) 15
14. Stem of claspette uniformly stout .. .. *annulipes* (Mg.).
Stem of claspette slender apically .. .. .. *excrucians* (Walk.).
15. Stem of claspette shorter and nearly straight 16
Stem of claspette longer and strongly curved 18
16. Appendage of claspette winged in the middle only, cylindrical on the basal third; basal lobe rather small, not pointed .. *detritus* (Hal.).
Appendage of claspette winged for its whole length or nearly; basal lobe produced and rather sharply pointed 17
17. Basal lobe much longer than broad; appendage of claspette extremely broad .. .. *maculatus* (Mg.).
Basal lobe scarcely longer than broad; appendage of claspette less broad *semicantans*, Mart.
18. Side-piece with short hair only 19
Side-piece with long hair arching over the upper surface 20
19. Basal lobe large, spine present though weak .. .. *freyi*, sp. n.
Basal lobe smaller, spine absent .. .. *parvulus*, sp. n.
20. Appendage of claspette with two slight ridges near the base *communis* (De G.).
Appendage of claspette with one ridge or wing, which is broadest in the middle 21
21. Aedoeagus and anal segment heavily chitinised .. .. *alpinus* (L.).
Aedoeagus and anal segment not unusually strongly chitinised 22
22. Lobes of ninth tergite with about six short straight bristles .. *cataphylla*, Dyar.
Lobes of ninth tergite with about twelve longer bristles which curve outwards .. .. *salinellus*, Edw.

1. **Aëdes (Ochlerotatus) caspius** (Pallas) (= *dorsalis*, Theo.) (fig. 8 a).

Culex caspius, Pallas, Reise versch. Prov. Russ. Reichs. i, p. 475 (1771).
Culex punctatus, Meigen, Klass, i, p. 6 (1804).
? *Culex siculus*, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. iii, p. 406 (1827).
Culex penicillaris, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
? *Culex leucogrammus*, Loew, Zeitschr. Ges. Naturw. xliii, p. 413 (1874).
Grabhamia subtilis, Ed. & Et. Sergent, Bull. Mus. Paris, xi, p. 240 (1905).
Grabhamia willcocksi, Theobald, Mon. Cul. iv, p. 294 (1907).
Grabhamia longisquamosa, Theobald, Ann. Mus. Nat. Hung. iii, p. 102 (1905).
Mansonia arabica, Giles, J. Trop. Med. p. 130 (1906).
Culex arabicus, Becker, Denkschr. k. Ak. Wiss. Wein. lxxi, p. 140 (1910).

As has often been pointed out, this is a very variable species, particularly as regards the abdominal markings. The palest specimens have the abdominal scales uniformly ochreous, while in the darkest the median pale stripe tends to be reduced, one Hungarian specimen which I have examined showing it on the second segment only. *A. caspius* may generally be known by the bright fawn-coloured scales of the mesonotum, with two narrow longitudinal stripes of white running the whole length, and by the even scattering of the dark scales over the wing-veins, as well as by the

shape of the basal lobes of the side-pieces of the male hypopygium. The variation in the thorax is in the direction of the reduction of the white scales, which are occasionally absent, especially in the male sex, where the reduction of the white lines is often accompanied by a more or less pronounced bleaching of all the mesonotal scales. There seems to be a slight difference between the north and south European forms in coloration, the Mediterranean type being lighter than the north European, and also somewhat smaller. The difference, however, is quite indefinite, and I see no necessity for the maintenance of a varietal name. Theobald's *G. longisquamosa* was evidently described from an extremely pale specimen. The variety *hargreavesi*, Edwards (Bull. Ent. Res. x, p. 130, 1920), seems to be well distinguished by having all the scales of the female mesonotum white; it is, however, known from only a very few rather imperfect specimens.

There are two main generations in the year (in June and September), and the species is often abundant enough to cause serious annoyance. It will often migrate some miles from its breeding-places (a habit common to most salt-marsh species), and is the only *Aëdes* in the European fauna which commonly enters houses. The adults are not known to hibernate, but Dr. Langeron captured a female at Gabes in January 1919.

The larvae show the reduction in the size of the anal gills which is commonly seen in salt and brackish-water species, but they are by no means confined to saline waters, the species often spreading far up the courses of the larger rivers, breeding in open meadows. It may be that specimens from fresher water have longer gills, as these organs certainly vary in length in this species. English specimens which I have examined agree with Martini's description in having the gills about two-thirds as long as the saddle, while Capt. Barraud's Mesopotamian specimens agree with Wesenberg-Lund's description in having gills only about one-third as long as the saddle.

Distribution.—European and Mediterranean coasts; Central European plain, and eastwards to the Gobi desert; desert regions of North Africa; Palestine; Persian Gulf; Punjab, as far inland as Rawalpindi. Apparently does not extend into North America. Since the species has been so much confused with *A. dorsalis*, it may be worth while to record some of the specimens I have examined from different museums: Denmark (near Copenhagen, *Wesenberg-Lund;* Finland (Kuustö, *Lundström*); France (Bourg la Reine, *Langeron*); Germany (Usedom, Sulldorf, *Litchwardt coll.*); Austria (Vienna, *Handlirsch;* Carniola, *Loitsch*); Hungary (Neusiedler See, *Handlirsch;* Hortobagy, *Kertész;* Csepel, *Bartko;* Fehertelep, *Ujhelyi;* Iszak, *Uhl;* Torda, *Biró*); Italy (Mehadia, Livorno, Spalato, *Mann*); Roumania (Tultscha, *Mann*); Constantinople (*Paris Mus.*); Asia Minor (Fregli, Tskehir, Kara, *Lendl*); Palestine (Jerusalem, *Goldberg*); West Caspian ("Lenkoran bis Elizabetpol, 1–2 Aug. Nachts. Schrecktl. Mücken-plage," *Berlin Mus.*); Transcaspia (Aschabad, Firudza, Tedjin and Kopet Dagh, *C. Ahnger*); Gobi Desert (Cha Tcheou, Marais de Pa-hou-lian, *Dr. L. Vaillant*).

2. **Aëdes (Ochlerotatus) dorsalis** (Meigen) (*nec* Theobald et al.) (fig. 8 b).

Culex dorsalis, Meigen, Syst. Beschr. vi, p. 242 (1830).
Culex maculiventris, Macquart, Dipt. Exot. Supp. i, p. 7 (1846).
Culex curriei, Coquillett, Can. Ent. xxxiii, p. 259 (1901).
Culex onondagensis, Felt, N.Y. State Mus. Bull. 79, p. 278 (1904).
Grabhamia broquettii, Theobald, Entomologist, xlvi, p. 179 (1913).
Aëdes grahami, Ludlow, Insecutor Inscitiae, vii, p. 154 (1920).

Doubt has been expressed by Wesenberg-Lund whether this is really distinct from *A. caspius*, but I still believe that the characters I have adduced are sufficient for the separation of the two, though it must be admitted that they are both variable species with entirely similar habits, and that they are frequently found together.

The thoracic scaling (brown to dark brown central stripe on front part of mesonotum only, with a broad creamy stripe on each side of it, dark brown again on the shoulders), wing scaling (preponderance of dark scales on the first, third and fifth veins, and of pale scales elsewhere), and the prominent basal lobes of the side-pieces of the male hypopygium will render the identification of nearly every good specimen certain.

I have decided to adopt the name *dorsalis* for this species for two reasons. First, I am indebted to M. Séguy for sending me a female from Meigen's collection labelled "Culex dorsalis. Berlin," probably in Meigen's own handwriting. As *C. dorsalis* was originally described from Berlin, it seems reasonable to accept this specimen as the actual type of the species. It is in good condition, and obviously *A. curriei*, not *A. caspius*. Secondly, from the descriptions of Staeger and Zetterstedt, as well as from some examples named by Staeger which were sent me by Dr. Wesenberg-Lund, it would seem that these writers based their conception of *C. dorsalis* mainly on *A. curriei*.

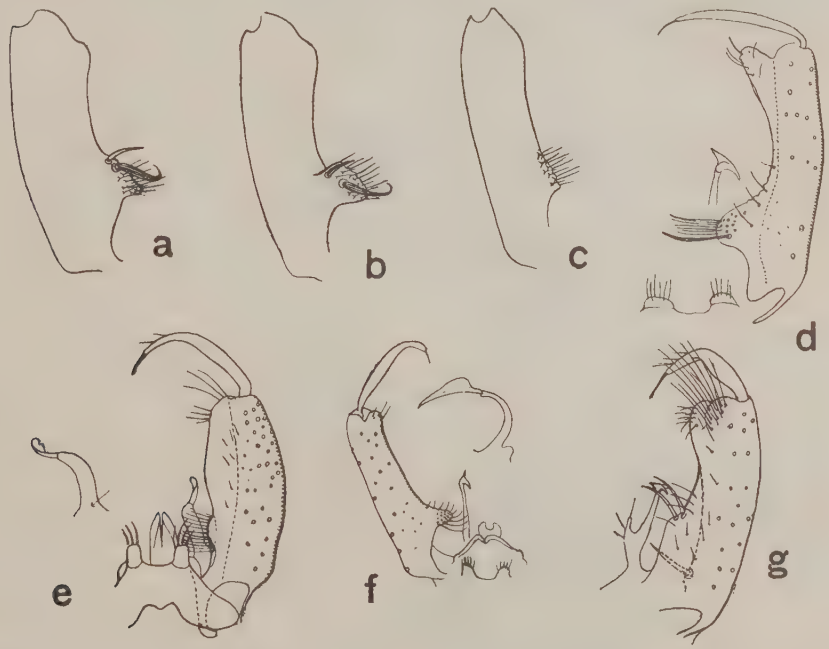

Fig. 8. Hypopygia of Palaearctic species of *Aëdes*: a, outline of side-piece, to show structure of basal lobe, of *A. caspius* (Pall.); b, the same, *A. dorsalis* (Mg.); c, the same, *A. mariae* (Serg.); d, hypopygium of *A. freyi*, sp. n.; e, hypopygium of *A. lepidonotus*, Edw., ventral view, claspette shown also in side view; f, the same, *A. parvulus*, sp. n.; g, *A. intrudens*, Dyar.

Rather contrary to expectation, Macquart's *C. maculiventris* proves to be this species and not *A. caspius*, according to the type female, which was sent me by M. Séguy.

The larva is at present only known from the description of Howard, Dyar and Knab; it has not yet been isolated in European collections. Specimens sent me by Dr. Dyar agree with the description in the monograph, and differ from *A. caspius* in at least three points: the siphon is distinctly more slender (index about 2·75 instead of about 2·3); the hair-tuft is scarcely beyond the middle of the siphon;

and the anal gills are very small and globular, not a quarter as long as the saddle. Whether these characters distinguish *A. dorsalis* as a species or merely the American race remains to be proved.

Distribution.—Coasts of northern Europe from France and southern England to Norway and the Baltic; Central European plain, and thence westward across Central Asia, China and North America as far as the Atlantic coast; North Africa (according to Macquart).

Some localities from which I have examined specimens are:—Denmark (*Wesenberg-Lund*); Sweden (Östergötland, *Haglund*); Finland (Kexholm, Eriksberg, Uskela, *E. J. Bonsd.*; Kuustö, *Lundström*; Soroka, *J. Sahlberg*); Germany (Berlin, *Meigen, Enderlein*; Usedom, Sülldorf, *Lichtwardt*; Halle, *Loew*); Austria (Hainfeld, *Mik*); Hungary (Budapest, *Kertész*; Budafok, *Bartko*; Fehertelep, *Ujhelyi*; Torda, *Biró*; Keczel, Hild, *Thalhammer*; Neusiedler-See, *Handlirsch*); North Russia (Waloniki, *Velitchkovsky*); Mongolia ("Vallée près de la Kouré de Bandie, 1500 m." and "Bords du Tarim," *Mission de Lacoste, Dr. du Chazaud*, 1909); Siberia (Irkutsk, *Schulz*); North China (Tinghai, *C. Ford*).

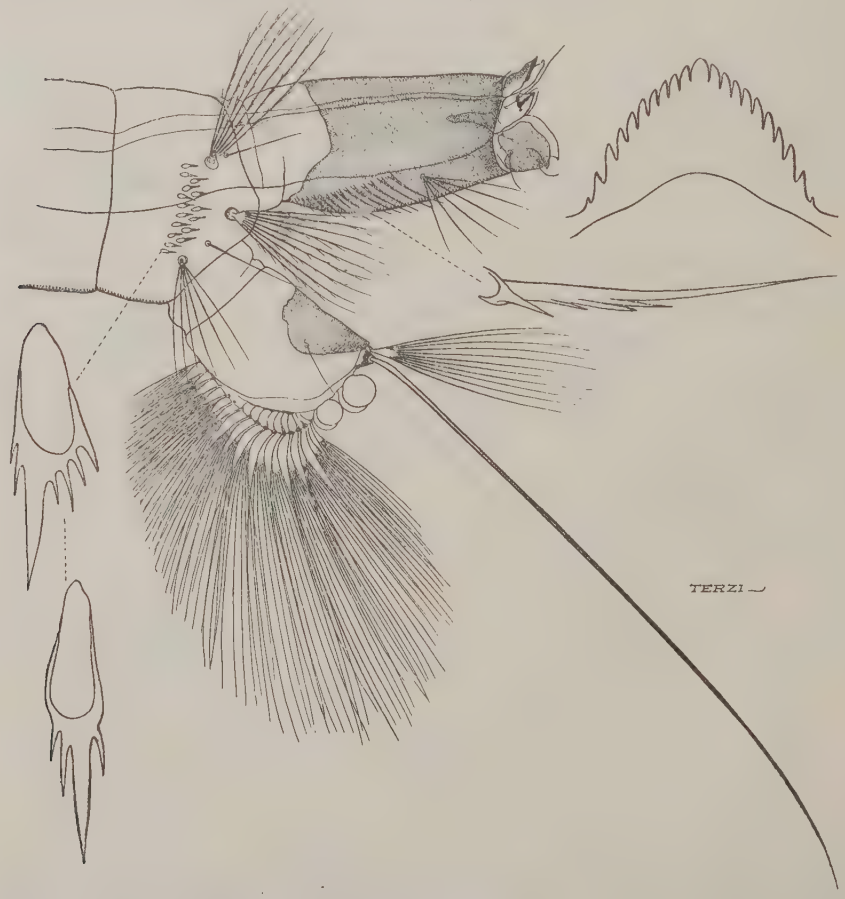

Fig. 9. *Aëdes mariae* (Serg.), end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

3. **Aëdes (Ochlerotatus) mariae** (Sergent) (figs. 6 b, 8 c, 9).

Culex mariae, Ed. & Et. Sergent, Ann. Inst. Pasteur, xvii, p. 62 (early in 1903).

Before having examined specimens of the true *A. pulchritarsis*, I took *A. mariae* to be synonymous with Rondani's species, but the two are in fact distinct. *O. mariae* has the wings, femora and tibiae, and even the tarsi in part, densely speckled with pale scales; the tarsal rings are creamy white and not very sharply marked; the mesonotal scales are almost uniformly ochreous without any bronzy tint. The male hypopygium resembles that of *O. caspius*, but the basal lobes of the side-pieces are smaller and carry no spines.

The Sergents' description of the larva being somewhat inadequate, fresh figures are given here, prepared from specimens collected by Capt. Barraud. These figures will explain themselves, but it may be specially noted that the antennae are almost devoid of small spicules, a very unusual character for this genus; the siphon is also remarkable in being almost as broad at the tip as at the base, the base being feebly or not at all chitinised (even in full-grown larvae); siphonal index 1·4–1·6. (It may be remarked here that Wesenberg-Lund's figure of the siphon of *A. caspius* is inaccurate; the tip in that species is really much narrower than the base.) The anal gills in *A. mariae* are minute and globular, as usual in salt-water breeders; the saddle is extremely small; formula of anal brush 10 + 4.

The species seems to be exclusively a salt-water breeder.

Distribution.—Algerian coast (*Sergent*); Southern France (*Séguy*); Palestine coast (Athlit, *Barraud*); Syria (Beirut, *Barraud*). Probably occurs also along the intervening Mediterranean coasts.

4. **Aëdes (Ochlerotatus) zammittii** (Theobald).

Acartomyia zammittii, Theobald, Mon. Cul. iii, p. 252 (25th July 1903).

This rather closely resembles *A. mariae*, the only difference I can detect in the adult being the presence of two more or less definite longitudinal stripes of white scales on the mesonotum, resembling those seen in *O. caspius*. The male hypopygia appear to be identical. The main reason for keeping the two distinct is the occurrence of certain larval differences. The two larvae of *A. zammittii* in the British Museum are both very much damaged, and one is immature, but the antenna has distinct spicules, and the pecten teeth are shorter, rather more numerous, closer together, and with more serrations than in *A. mariae*; it is possible they may have been wrongly associated with the adults, and in any case it is very desirable that more and better material should be obtained. If *A. zammittii* should prove identical with *A. mariae*, the latter name will stand for the species; it must have been published earlier, since Theobald quotes it (Mon. Cul. iii, p. 354).

Distribution.—Originally described by Theobald from Malta. I have also seen specimens with a more or less distinctly white-striped thorax from Palma, Majorca (*Grünberg*), and Southern France (*Dollfus, per Dr. Langeron*).

5. **Aëdes (Ochlerotatus) pulchritarsis** (Rondani).

Culex pulchritarsis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Culex leucacanthus, Loew, Beschr. Eur. Dipt. iii, p. 1 (1873).

In the specimens which I have examined there are no pale scales on the wings, the femora and tibiae are moderately speckled; the tarsi are black, with sharply marked white rings; the mesonotal scales rather variable, usually dull bronzy-ochreous with some patches of darker ones, sometimes, as in the specimens from Paris and Chitral, a more or less distinct central white stripe. It is just possible that the species may not be correctly identified, since Ficalbi in his detailed description says of the

wings, "con qualche brizzolatura chiaro." Ficalbi's description, however, fits this species much better than it does *O. mariae*. The two Italian specimens were both determined by Prof. M. Bezzi, who has seen Rondani's collection. Judging from the description, it seems highly probable that Loew's *C. leucacanthus* is the same species.

The larva is unknown. The male hypopygium differs from that of *A. mariae* and *A. zammittii* in having a single distinct spine on the basal lobe of the side-piece, the structure being otherwise similar.

Distribution.—Italy (Toscana, near sea, *Ficalbi;* Faenza, *E. Hargreaves;* Macerata, *Bezzi*); Macedonia (Bajirli, near Snevce, *Waterston*); Persia (Kasan, *Loew*); Paris (*Berland, Séguy*); Croatia (Novi, *Horváth*); Chitral (Drosh, *Walker*, 1915; *per Capt. P. J. Barraud*).

6. **Aëdes (Ochlerotatus) maculatus** (Meigen) (fig. 7 a).

Culex maculatus, Meigen, Klass. und Beschr. i, p. 4 (1804).
Culex cantans, Meigen, Syst. Beschr. i, p. 6 (1818).
Culicada waterhousei, Theobald, Ann. Mag. Nat. Hist. (7), xvi, p. 674 (1905).

This species may generally be distinguished from others of the group by its darker colour; the femora (especially the hind pair) have more numerous dark scales, the white rings on the tarsi are narrower, and the mesonotum is much darker, the pale scales occurring mainly on the posterior third and often forming a pair of spots just behind the middle and indistinct pale lines in front of the scutellum. There appear to be two more or less definite forms: a smaller, with entirely dark-scaled wings and distinct pale bands at the bases of the abdominal tergites, and a larger, with scattered pale scales on the wings and the abdominal bands more or less obsolete, the pale scales which are present occurring as much towards the apices as the bases of the segments. The peculiar male hypopygium, with its divided basal lobes and very broad appendage to the claspettes, is the same in both forms.

I am still unable to distinguish satisfactorily the larvae of *A. maculatus* and *A. annulipes*,* but the two species are certainly quite distinct. *A. maculatus* is essentially a woodland species, while *A. annulipes* (and most others of the group) prefer more open breeding-places.

This species has generally been known as *A. cantans*, though Meigen's description will apply as well or better to one of the other species of the group. For this reason Lang adopted the later name *waterhousei*. M. Séguy, however, informs me that males of this species are labelled *C. cantans* in Meigen's collection in Paris, and the identification of Theobald, de Meijere and others must therefore be regarded as correct. Meigen himself states that his *C. maculatus* was the male of *C. cantans*, and this statement must be accepted, since the type of *C. maculatus* no longer exists to prove or disprove it. Many of the earlier records of *C. cantans* apply no doubt to other species of the group.

Distribution.—Apparently confined to Europe, occurring chiefly north of the Alps. I have seen males from Britain; France (*Séguy, Langeron*); Belgium (*Goetghebuer*); Denmark (*Wesenberg-Lund*); Sweden (Stockholm, *Boheman;* Småland, *Haglund*); Finland (Kymmene, *Sallm.*); Germany (Urdingen and Frankfort-an-der-Oder, *Riedel;* Berlin, *Oldenberg, Lichtwardt*); Austria (Polzleinsdorf, *Schiner;* Moritzburg, *Kuntze*); Hungary (Munkács, *Ujhelyi*); also females, probably of this species, from Lappland (Qvikkjokk), and Italy (Turin, *Sangone, coll. Bezzi*).

* Séguy's figure of "*A. cantans*" in Bull. Mus. Paris, 1920, p. 327, really represents *A. communis*; his later figure of "*O. cantans*" in Bull. Soc. Ent. France, 1920, p. 310, probably represents *A. lutescens* (see Séguy, Bull. Soc. Ent. France, 1921, p. 165).

7. **Aëdes (Ochlerotatus) semicantans,** Martini (fig. 7 b).

Aëdes semicantans, Martini, Arch. f. Schiffs- und Tropenhyg. xxiv, Beiheft 1, p. 247 (1920) (diagnosis only), and Sitzb. u. Abh. natf. Ges. Rostock, vii, p. 205 (1920).

Resembles *A. maculatus* in coloration, being darker than the other four species of the group; the mesonotum has a more definite dark median stripe than in *A. maculatus,* and the abdominal segments have distinct basal white bands, which are narrowed in the middle, but the two are not easily separated, except by characters of the male hypopygium and larva, which are perfectly distinct. The hind femora are largely pale on the outer side, and the tarsal rings are broader than in *A. maculatus.* One or two North American species resemble this rather closely, but I have not at present been able to identify *A. semicantans* definitely with any North American form. The larva is very distinct on account of the small number of scales in the comb of the eighth segment.

Distribution.—Northern Europe; apparently widely distributed, but local. I have seen males from Sweden (Småland, *Boheman*); Germany (Hamburg, *Martini;* Berlin, *Stobbe;* Posen?, *Loew*); Austria? (*coll. Winthem*).

8. **Aëdes (Ochlerotatus) annulipes** (Meigen) (fig. 7 e).

Culex annulipes, Meigen, Syst. Beschr. vi, p. 241 (1830).
Aëdes quartus, Martini, Über Stechmücken, p. 128 (1920).

Meigen mentions the dark stripe in the middle of the mesonotum, the banded abdomen and pale femora, and I therefore have no doubt that the species is correctly identified. Zetterstedt, Ficalbi and others who have described the entirely yellow abdomen of the female probably had *A. lutescens* before them. In this species the abdomen almost always has distinct yellowish-white bands, which are situated mainly or entirely at the bases of the segments.

The larva is of the short-siphoned type, apparently identical with that of *A. maculatus* (except that the siphon is slightly shorter on the average), but very distinct from that of *A. excrucians.* It occurs typically in open swamps.

Distribution.—I have examined male specimens from England (various localities); Holland (Ghent, *Theobald*); Belgium (Wesembeek, *Tonnoir*); Germany (Urdingen, *Riedel;* Berlin, *Oldenberg*); Lower Austria (Speising, *Mik*); Hungary (Pressburg, *Mik;* Tultscha, *Mann*). A female from Sweden (Östergötland, *Haglund*) may be this species, but is perhaps more probably *A. excrucians.* Mårtini records it from the neighbourhood of Hamburg and Dantzig. It may be regarded as the western European representative of *A. excrucians,* though the ranges of the two species must overlap to some extent.

9. **Aëdes (Ochlerotatus) excrucians** (Walker) (fig. 7 f).

Culex excrucians, Walker, Ins. Saund. Dipt. p. 429 (1856).
Culex abfitchii, Felt, Bull. N.Y. State Mus. 79, p. 381 (1904); et auct.
(?) *Culicada surcoufi,* Theobald, Bull. Mus. Paris, xviii, p. 59 (1912).
Aëdes excrucians, Dyar, Insecutor Inscitiae, vii, p. 25 (1919), and viii, p. 109 (1920).

This species is most nearly allied to *A. annulipes,* but the abdomen is less distinctly banded, the dark bands being reduced to a more or less diamond-shaped spot on each segment; the dark colour is often more extensive in the female. The mesonotum usually has some obscure markings; rarely a distinct, broad, dark median stripe as in *A. annulipes.* The difference of structure in the male claspettes is slight but well defined. I can see no difference between American and European specimens, except that in the former the pale markings are cream-coloured rather than yellowish.

A. excrucians is evidently one of the commonest species of the group on the European continent (it has been described by Martini as *A. abfitchii*), and it is therefore

not surprising that it has frequently been determined either as *C. cantans* or as *C. annulipes*. I consider, however, that the evidence of the original descriptions and of the types in Meigen's collection in Paris is sufficient to allot these names to other species.

I learn from M. Séguy that the type male of *Culicada surcoufi* has been lost, so that there is now very little prospect of determining Theobald's species with certainty. A female which M. Séguy sent me for examination might have been either this species or *A. annulipes*. A female in Meigen's series of *C. cantans* in the Paris Museum is almost certainly *A. excrucians*.

Distribution.—I have examined male specimens from the following countries :— Finland (Hattula, *L. v. Essen;* Tvarminno, Messuby and Walkj, *R. Frey ;* Eriksberg, *E. J. Bonsd. ;* Karislojo, *J. Sahlberg*) ; Sweden (Södermanland, *Aurivillius ;* Östergötland, *P. Wahlberg*) ; Denmark (*Wesenberg-Lund*) ; Germany (Berlin, *Lichtwardt, Oldenberg, Stobbe, Enderlein*) ; Austria (many in Winthem's old collection without definite data ; one male labelled " rufibarbis, Gtl.") ; Hungary (Buda, *Biró ;* Munkács, *Ujhelyi ;* Berecsasz, *Kertész*) ; Saghalin Island (*Paul Labbe*, 1902). In addition I have seen many females which are probably this species, but cannot be determined with absolute certainty, including some from Siberia (Antsiferovo, 59° 10′, and Turuchansk, 65° 55′, *Trybom*). The species may therefore be assumed to have a continuous distribution over North Europe and North Asia ; it is also known to be widely spread in North America. It appears to be absent from North-western Europe.

10. **Aëdes (Ochlerotatus) freyi,** sp. n. (figs. 7 d, 8 d).

Scales of head and mesonotum all small and yellow. Abdomen yellow, the tergites with black apical lateral patches, no median dark line. Male palpi longer than the proboscis by nearly the length of the last joint. Long joint with a yellow ring at the base and another beyond the middle ; last two joints pale-scaled at the base ; hairs long, brown. Proboscis all black. Tarsi with white rings at the bases of the joints ; those on the middle joints of the hind tarsi slightly more than half of the length of the joints. Front and middle femora speckled in front, yellow behind ; hind femora mostly yellow, with some black scales towards the tip. Wing-scales mostly dark, the costa yellow on about the basal third.

Hypopygium : side-pieces rather slender, fully three times as long as their greatest breadth. Basal lobe prominent, rounded apically, with a small patch of long hair, and a single long, weak, pale spine. Apical lobes rather large, somewhat pointed, with a few longish hairs. No arching-hairs on sternal side of side-piece. Claspette with long curved stem and broadly flattened appendage, the expansion commencing at the base. Lobes of ninth tergite each with about six short hairs.

This species, though resembling *A. lutescens* in coloration and *A. semicantans* in the structure of its hypopygium, is certainly distinct from both. The few examples I have seen are all more or less damaged and do not allow a very precise definition of the species on colour characters. Possibly the costa being yellow towards the base only instead of for the greater part of its length might distinguish the female of *A. freyi* from that of *A. lutescens*. The only undoubted female of *A. freyi* I have seen was considerably denuded ; it had scattered light scales on the wings, and the proboscis largely pale except towards the base and tip.

Distribution.—Finland (Eriksberg, *E. J. Bonsd.*, type male in Helsingfors Museum) ; Germany (Berlin-Finkenkrug, 27.v.00, *L. Oldenberg*, 3♂, 1♀).

11. **Aëdes (Ochlerotatus) lutescens** (Fabricius) (fig. 7 c).

(?) *Culex flavescens*, Müller, Fauna Insectorum Friedrichsdalina, p. 87 (1764).
Culex lutescens, Fabricius, Syst. Ent. p. 800 (1775).
(?) *Culex variegatus*, Schrank, Enum. Ins. Austr. p. 482 (1781).

Culex flavescens, Fabricius, Syst. Antl. p. 35 (1805).
(?) *Culex bipunctatus*, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii p. 405 (1827).
Culex flavus, Motchulsky, Bull. Soc. Imp. Nat. Moscow, xxxii, pt. 2, p. 503 (1859).
Culex flavescens, Theobald, Mon. Cul. i, p. 410 (1901).
Culex arcanus, Blanchard, Les Moustiques, p. 303 (1904).
Culex fletcheri, Coquillett, U.S. Bur. Ent. Tech. Ser. 11, p. 20 (1906).
Aëdes cyprius, Ludlow, Insecutor Inscitiae, vii, p. 158 (1920).

Although this species seems to be subject to a good deal of variation, it may probably always be recognised by the predominantly yellow-scaled costa and the mainly or entirely yellow-scaled abdomen. In the lightest specimens the proboscis is yellow-scaled except at the tip, where the scales are black; the palpi and wings are almost entirely yellow-scaled; the mesonotal scales are rather light yellow; the thoracic integument is reddish, with a black patch in front from which three black lines extend backwards; the abdominal scales are all yellow in the female, usually with a median line of dark ones in the male; the tarsi, though with the usual white rings at the bases of the joints, have the dark portions largely replaced by yellow, except at the tips of the joints. In the darkest specimens the proboscis and palpi are almost entirely black-scaled, the wings are much darker, even the costa having a considerable sprinkling of dark scales; the mesonotal scales are rather deep brown, contrasting strongly with the white scales of the pleurae; the thoracic integument is nearly all black; the female abdomen has rather numerous dark scales at the sides; and the tarsi are darker. In some males the thoracic scales are almost white, and there are traces of a darker median band.

It is possible that the two forms above described may represent distinct varieties, or even species, but they appear to intergrade, and males associated with both dark and light females have practically identical hypopygia, the only difference observed being that some (though not all) of the light specimens had a more or less definite hook to the membrane of the claspette appendage (see fig. 7 c). Apart from this the hypopygium is well distinguished by the shape of the side-pieces, the very large basal lobes bearing a strong black spine, and the appendages of the claspettes, which have no membranous expansion on the basal third.

I at first considered that *A. lutescens* was identical with the American *A. fletcheri*, but there are some slight differences: in *A. fletcheri* the apical lobe of the side-piece of the male hypopygium is smaller, and the mesonotum has a distinct broad dark central stripe.

This, being a common European species, is much more likely to be Fabricius' *C. lutescens* than the rare one which Theobald has redescribed as such. Fabricius emphasises the yellow costa and the yellow proboscis with a black tip; he does not mention the tarsi, the statement that they are dark being due to Meigen, who may have had another species before him. Martini was of the same opinion regarding Fabricius' species, but did not adopt the name; I consider the identification sufficiently probable for the name to be used. Zetterstedt, Ficalbi and Martini use the name *annulipes*, Mg., for it, but this is certainly wrong, since the abdomen is never banded, as Meigen states is the case in *annulipes*. Although Motchulsky's diagnosis is very brief, I consider it highly probable that his *C. flavus* is our *A. lutescens*.

Distribution.—Europe, except the west; Siberia; extending in a slightly modified form into North America. I have seen specimens from Denmark (*Wesenberg-Lund*); Sweden (Östergötland, Scania, *Boheman*, light females); Finland (Kuustö, *Lundström*; Eriksberg, *E. J. Bonsd.*); Germany (Berlin, *Wanen, Lichtwardt, Oldenberg, Tetens*, females of light and dark forms; Radoj, *Loew*, dark female); Austria (Mödling, *Pokorny*; Michelstettin, *Bischoff*; Sterize, Styria, *Mann*; Weyshi, Steiermark, *Mann*; males, and females of dark form); Hungary (Pressburg,

Mik; Jaszenova, *Ujhelyi;* Kovákspatak, *Kertész;* Budapest, *Csiki,* males; Neusiedler See, *Mik,* and Munkacs, *Ujhelyi,* dark females); Ural (Winthem, light female); Siberia (Nasimovo, 59° 35′, males and dark females; Nikulina, 60° 25′, lighter male, *Trybom;* Omsk, *Granö,* light females); Kamtchatka (Bolsherjetsk, 20.vii.17, *Y. Wuorentaus,* light female); Asia Minor (Seraj-Koj, *Naday,* dark females).

12. **Aëdes (Ochlerotatus) rusticus** (Rossi).

Culex rusticus, Rossi, Fauna Etrusca, ii, p. 333 (1790).
? Culex musicus, Leach, Zool. Journ. ii, p. 293 (1825).
Culex pungens, Robineau-Desvoidy, Mem. Soc. Hist. Nat. Paris, iii, p. 407 (1827).
Culex quadratimaculatus, Macquart, Suites à Buffon, i, p. 34 (1834).
Culex diversus, Theobald, Mon. Cul. ii, p. 73 (1901).
Culex nemorosus var. *luteovittatus,* Theobald, Mon. Cul. ii, p. 85 (1901).

This is the largest species of the dark-footed group of the subgenus, and is very distinct from all the rest in the structure of the hypopygium and larva. The male has the palpi stouter than in most species; it can generally be distinguished even by the naked eye on account of the dense golden-yellow hairs which arch over the hypopygium, hiding the claspettes. The most strongly-marked form of the female, on which I have presumed Rossi's and Robineau-Desvoidy's original descriptions were based, shows a yellowish longitudinal stripe running the whole length of the abdomen, and dividing the black scales into two squarish areas on each segment; but it is commoner to find this longitudinal stripe distinguishable only on the last two or three segments, and such specimens will sometimes have to be examined carefully to avoid confusion with other species, such as *O. punctor* and *O. communis.* The pro-epimeral scales will separate it immediately from all other Palaearctic species.

An interesting variation is shown in a female from Szeged (*Kertész*), which has the abdomen almost entirely covered with yellowish scales, the black ones occurring only towards the middle of some of the segments without forming definite markings; the mesonotal scales are also much paler than usual, especially towards the sides. The pro-epimeral scales are normal for the species. A similar specimen from Budapest has been described by Theobald (Mon. Cul. iv, p. 344) as *Culex lutescens,* but, as stated above, I prefer to use Fabricius' name in another sense.

Walker (List Dipt. Brit. Mus. i, p. 8) queries *C. musicus* as the same as *C. quadratimaculatus.* The synonymy indicated may be correct, but the specimens are no longer in existence.

The larva is one of the few in this genus which lives through the winter, though perhaps many of the eggs do not hatch until the early spring. There is some individual variation in the number of hairs on the antero-dorsal side of the siphon.

Distribution.—West, central and south Europe. Locally common in England, France, Belgium, Germany and Denmark. Also Italy (*Rossi;* Taranto, *Hargreaves;* Livorno, *Mann*); Macedonia (*Waterston*). Not yet recorded from Sweden, Finland, Russia or Asia.

13. **Aëdes (Ochlerotatus) lepidonotus,** Edw. (figs. 5 b, 5 f, 8 e.)

Ochlerotatus lepidonotus, Edwards, Bull. Ent. Res. x, p. 132 (1920).

Distinguished by the characters given in the keys and by the uniformly pale-scaled abdomen of the female. The larva is unknown.

Distribution.—Macedonia (*Waterston*).

14. **Aëdes (Ochlerotatus) albescens,** sp. n.

Apparently related to *A. lepidonotus,* Edw., but the postnotum bears no scales. Almost all the scales of the body whitish, except on the proboscis and palpi, where they are mostly brown. Pro-epimeral scales whitish, rather narrow, some of them

curved. Palpi rather long, nearly one-third as long as the proboscis. Wings rather scantily scaled (not rubbed); veins all pale, membrane whitish; costal scales all whitish-yellow; first longitudinal vein with some dark scales. Integument of legs pale yellow, scales almost all whitish-yellow, those on the terminal tarsal segments browner; no sign of pale tarsal rings. Claws all toothed. Integument of thorax and abdomen blackish.

W. Siberia: Omsk (*Granö*); 1♀. Type in Helsingfors Museum.

15. **Aëdes (Ochlerotatus) alpinus** (Linn.).

Culex alpinus, Linnaeus, Flora Lapp. Ed. 2, p. 381 (1792).
Culex nigripes, Zetterstedt, Ins. Lapp. p. 807 (1838); Henriksen and Lundbeck, Med. Groenland, xxii, p. 595 (1917).
Aëdes innuitus, Dyar and Knab, Insecutor Inscitiae, v, p. 166 (1917).
Aëdes (*Ochlerotatus*) *nearcticus*, Dyar, Rept. Canad. Arctic Exp. iii, Pt. C, p. 32 (1919).
Aëdes alpinus, Dyar, Insecutor Inscitiae, viii, p. 52 (1920).

This species is fairly readily distinguishable by the unusually dense bristles on the thorax, looking, as Dyar has remarked, "as though it had a long woolly coat to keep out the cold." The very dark colour of the mesonotal scales, the black integument of the whole body, and the straight, shining greyish-white abdominal bands are also characteristic. However, since the density of the bristles is somewhat variable (smaller specimens being less bristly), and they are also rather liable to denudation (though less so than the scales), it is not always easy to distinguish the species from *A. cataphylla* and *A. parvulus*. In fact *A. alpinus* might almost be regarded as a race of *A. cataphylla* which has become adapted to arctic conditions by the multiplication of its bristles and the thickening of the chitin of the whole body.

I have failed to obtain a European male for examination from any correspondent, and it is very unfortunate that the good series of the species brought from north Russia by Capt. Carment and Dr. E. A. Cockayne consisted of females only. I am, however, indebted to Prof. Sjöstedt and Dr. Lundbeck for several males from south-west Greenland. These differ from the females (from the same place) in showing hardly any scales on the thorax; consequently they appear a good deal blacker; they are also even more hairy, especially on the abdomen. The hypopygium very much resembles that of *A. cataphylla*, except in being far more heavily chitinised, especially in the anal and genital parts. The apical lobe of the side-piece is very small, hardly distinguishable; the basal lobe has a moderately stout spine.

It seemed highly probable that these Greenland specimens were *A. innuitus*, D. & K., but that species was described as having a "double angular membrane" on the appendage of the claspette, as in *A. lazarensis*, while the males I have examined showed the normal single membrane. Dr. Dyar therefore re-examined the types of *A. innuitus*, and reports that the original description was in error; the membrane is really single, and the structure of the hypopygium of *A. innuitus* and *A. nearcticus* is really identical. That being so, there can be little doubt that *A. alpinus* is also the same, especially since we now know that a number of northern species of *Aëdes* are common to the Old and New Worlds.

Distribution.—Probably a circumpolar species, occurring in all the lands to the north of the Arctic Circle. I have seen males and females from south-west Greenland, and females from Finmark, Lappland, Murmansk, and north-west Siberia; also a female from the Paris Museum labelled "Fontainebleau, Dufour et Laboulbène." In regard to this last there must surely have been some mistake in labelling.

16. **Aëdes (Ochlerotatus) detritus** (Hal.) (fig. 7 h).

Culex detritus, Haliday, Entom. Mag. i, p. 151 (1833).
Culex salinus, Ficalbi, Bull. Soc. Ent. Ital. xxviii, p. 29 (1896).
Culex terriei, Theobald, Mon. Cul. iii, p. 193 (1903).

This species is subject to a good deal of variation. Normally the dark parts of the abdomen are speckled over with light scales, but these are sometimes absent. Normally also the male palpi are entirely dark-scaled, but specimens are not infrequently met with in which the long joint bears a good many pale scales on its apical half. When both these variations occur together the specimens are not easy at first sight to distinguish from *A. salinellus*. Apart from the structure of the male hypopygium, which is of course diagnostic, the best distinctions are to be found in the almost uniform brown colour of the mesonotal scales of *A. detritus*, and the row of black spots down the middle of the venter, which are usually conspicuous in living specimens, though they are not so easily seen in the dry.

So far as known, the larva is confined to salt or brackish water, and, as in many other such forms, the gills are greatly reduced in size.

Distribution.—European coasts, from Ireland and France to Denmark and Macedonia; also coasts of North Africa, Suez Canal and Palestine. Apparently does not occur inland in eastern Europe, as do its frequent associates *A. caspius* and *A. dorsalis*. I have, however, seen a single male specimen, with a hypopygium identical with that of European *A. detritus*, from Kashgar, Chinese Turkestan (*Racquette*, in Stockholm Museum).

17. **Aëdes (Ochlerotatus) cataphylla,** Dyar, var. **rostochiensis,** Martini (fig. 7 l).

Aëdes cataphylla, Dyar, Insecutor Inscitiae, iv, p. 86 (1916).
Aëdes prodotes, Dyar, Insecutor Inscitiae, v, p. 118 (1917).
Aëdes rostochiensis, Martini, Über Stechmücken, p. 246, diagnosis only (1920), and Sitzb. u. Abh. natf. Ges. Rostock vii, p. 204 (1920).

This species and *A. salinellus* are together distinguished by the pale-speckled femora and the more or less conspicuous pale ring towards the end of the long joint of the male palpi; they differ from *A. detritus* in never having scattered pale scales on the dark parts of the abdomen, though the eighth segment is generally almost entirely pale. The two species *A. cataphylla* and *A. salinellus* are extremely alike; the most obvious difference in the adult is in the colour of the scales of the proboscis, which in *A. cataphylla* are almost all black, in *A. salinellus* extensively pale about the middle, but I am not sure how far this difference is constant. There is a slight but fairly well defined difference in the hypopygia (indicated in the key), but the most striking character of *A. cataphylla* is the presence of a couple of disconnected spines at the end of the pecten of the larval siphon.

None of the old European names seem to be applicable to this species, but I am satisfied that it is specifically identical with the western North American *A. prodotes*, Dyar (which Dyar now recognises to be the same as his previously described *A. cataphylla*). The male palpi have the same pale ring; the larva has the same two detached spines on the pecten, and the hypopygia are identical, except for a slight difference in the size of the apical lobes of the side-pieces. The American specimens, however, are on the average smaller, and the mesonotal scaling is rather different from the usual European type, being rather darker in the middle and with more numerous white scales at the sides. Nevertheless the Norwegian specimens in the British Museum have the sides of the mesonotum even whiter than the American specimens I have examined.

Distribution.—I have seen male specimens from Denmark (*Wesenberg-Lund*); Sweden (Småland, Stockholm and Dalecarlia, *Boheman*); Norway (Smaalenene,

Prof. O. Collet) ; Finland (Jämsa, *Bergroth ;* Helsingfors ; Hattula, *L. v. Essen ;* Finnström, *Frey ;* Sund, *Forsius ;* Karislojo, *J. Sahlberg ;* Kuusamo, *Frey*) ; Germany (Frankfurt-Oder, *Riedel ;* Berlin, *Oldenberg*) ; Austria (Prater, *Mann :* this specimen was insufficiently examined and may have been *A. salinellus*) ; Siberia (Yeniseisk, 58° 20′, *Trybom*).

18. **Aëdes (Ochlerotatus) salinellus,** Edw. (fig. 7 k).

Aëdes salinellus, Edwards (?) in Wesenberg-Lund, K. Danske Vid. Selsk. Skr. Nat. Math. Afd. vii, p. 197 (1921).
Ochlerotatus salinellus, Edwards, Ent. Tidskr. p. 52 (1921).
Aëdes terriei, Martini (*nec* Theo.), Über Stechmücken, p. 112 (1920).

The distinguishing points of this species have been mentioned under *A. cataphylla*. In spite of their close similarity, there can be little doubt that the two species are distinct. I am not satisfied that any older name can be applied to this species. The type of *C. terriei* is certainly nothing but a normal, if rather small, female of *A. detritus*, which is common in the locality where *C. terriei* was taken. It is quite possible that *A. salinellus* may eventually be found to be the same as some known American species, but at present I have not been able to identify it with any such ; it may be the European representative of *A. impiger* (=*decticus*, H.D.K.), which has the male palpi all black and fewer bristles on the ninth tergite.

The name *salinellus* was suggested partly because of the strong resemblance to *A. detritus* (*salinus*), and partly because the first specimens sent me by Dr. Wesenberg-Lund were reared from brackish water.

Distribution.—Northern and central Europe. I have seen males from England (Nottinghamshire, *Carr*) ; Denmark (*Wesenberg-Lund*) ; Germany (Berlin, *Oldenberg, Lichtwardt ;* Kiel, *Wiedemann*) ; Austria (Vienna, *Pokorny*) ; Hungary (Budapest, *Kertész ;* Bethlen, *Ujhelyi ;* Pöstyén, *Lichtwardt*). Also some small females, probably of this species, from south Russia (Waloniki, *Velitschkovsky*). Martini records it from various places in north Germany, generally near the sea, sometimes in company with *A. detritus*.

19. **Aëdes (Ochlerotatus) diantaeus,** H.D.K.

Aëdes diantaeus, Howard, Dyar and Knab, Mosq. N. & C. Amer. iv, p. 758 (1917).
Aëdes serus, Martini, Über Stechmücken, p. 96 (1920).

An extremely distinct species in larva and male hypopygium ; less well defined in the female, but recognisable by the deep bluish-black colour of the tibiae and tarsi, and the broad black stripe down the middle of the mesonotum. Owing to the colour of the legs, and the usually interrupted pale bands of the abdomen, the female might easily be mistaken for *A. geniculatus*, which of course differs in the structure of the tip of the abdomen, as well as in thoracic markings. I have compared adults and larvae of European and North American specimens, and can find no difference, except in the length of the anal gills of the larva, which is known to be a variable character. Neither of the published figures of the hypopygium is very accurate ; in particular it should be noted that Martini's omits altogether the conspicuous hair-tuft of the side-piece.

Distribution.—I have examined the following European material :—Finland (Kuustö, Kuusamo and Küminki, *R. Frey*) ; Denmark (*Wesenberg-Lund*). Martini's material presumably came from the Hamburg district.

20. **Aëdes (Ochlerotatus) sticticus** (Meigen).

(?)*Culex lateralis,* Meigen, Syst. Beschr. i, p. 5 (1818).
Culex sticticus, Meigen, Syst. Beschr. vii, p. 1 (1838).

Culex concinnus, Stephens, Illustr. Brit. Ent. Suppl. p. 19 (1846).
Culex nigripes var. *sylvae*, Theobald, Mon. Cul. ii, p. 96 (1901).
Culicada sylvae, Theobald, Mon. Cul. iii, p. 194 (1903).
(?) *Aëdes aldrichi*, Dyar & Knab, Proc. U.S. Nat. Mus. xxxv, p. 57 (1908).
Culicada nigrina, Eckstein, Centralbl. f. Bakt. Abt. Orig. lxxxii, p. 67 (1918).
Culex nemorosus var. *dorsovittatus*, Villeneuve, Bull. Soc. Ent. France, p. 57 (1919).
Ochlerotatus dorsovittatus, Séguy, Bull. Mus. Paris xxvi, p. 408 (1920).
(?) *Ochlerotatus lesnei*, Séguy, Bull. Mus. Paris xxvi, p. 328 (1920).
Culicada nemorosa salina, Brolemann (*nec* Ficalbi), Ann. Soc. Ent. France, lxxxviii, p. 81 (1919).

This species is fairly easily recognisable by the general blackish colour, the white scales on the sides of the mesonotum, contrasting strongly with the dark brown stripe which occupies the middle third, and the whitish stripe on the outer side of the hind tibia of the female (often, though not always, present also in the male). The hypopygium (figured by Séguy and Brolemann) is characterised by the extremely short appendage to the claspette, which is very little longer than broad, and not much broader than the width of the stem, and by the large basal lobes, which are to a great extent separated from the side-pieces.

The species varies a good deal in size, though it is on the average smaller than *O. punctor*, to which it is most nearly allied. It also varies in regard to the abdominal bands of the female, which are in some specimens reduced to lateral spots (as in the type of *C. sticticus*, and as described by Eckstein for *C. nigrina*), while in others they are complete and scarcely even contracted in the middle (as in the types of *C. concinnus* and *C. sylvae*). I do not believe that these differences represent anything more than individual variation. Eckstein describes and gives rough figures of a difference between the hypopygia of his *C. nigrina* and what he regards as *C. lateralis*, stating that the appendage of the claspette is shorter and less broad in the latter than in the former. This may be true, and if so must indicate that we are dealing with two distinct species, but I have seen no specimens corresponding to Eckstein's figure of *C. lateralis*, and am inclined to think he has merely shown the same structure from two different points of view.

Since there may be two allied species here, and since there has been difference of opinion as to the interpretation of Meigen's *C. lateralis*, Theobald using the name for *A. geniculatus*, it does not seem advisable to adopt this earlier name for the species; the type of *C. lateralis* being no longer in existence, it seems best to follow Theobald in adopting Ficalbi's suggestion that it is the same as *C. albopunctatus*, Rond. (*A. geniculatus*). Of *C. sticticus* there is a female in good condition in Meigen's collection at Paris, and Séguy reports that the hind tibiae have a distinct pale stripe on the outer side. The name *sticticus* may therefore be used without further question.

I have examined the types of *C. concinnus* and *C. sylvae* and cotypes of *C. dorsovittatus*, and have no doubt as to their identity. Séguy's figure of the hypopygium of *O. lesnei* represents a structure apparently identical with that of *A. sticticus*, his other figure of *O. dorsovittatus* being rather inaccurate, besides showing the same structure in a different position. Specimens of *A. sticticus* were collected by M. Lesne in the same locality and at the same time as the type of *O. lesnei*, and I cannot help thinking that Séguy has confused two different species in his description: the tarsi of *O. lesnei* are said to have pale rings.

The North American species *A. hirsuteron* (Theo.), *A. aestivalis*, Dyar, and *A. aldrichi*, D. & K., are all very similar to *A. sticticus* in coloration, as well as in the male hypopygium, all having the same peculiar structure of the basal lobes. It is not at all unlikely that *A. sticticus* occurs in North America under one or other of these names. I can see no difference between European *A. sticticus* and American *A. aldrichi*, and consider that they are most probably identical, though distinctions

may be discovered on closer study, especially when the European form is better known.

According to Eckstein the larva of *A. nigrinus* lives in flooded meadows together with *A. vexans* and *A. dorsalis*, and several generations are passed through during the year. This does not accord with what is known of the habits of the allied North American species.

Distribution.—Widely spread in Europe, but seems to be nearly always rare. I have seen specimens (mostly females) from Scotland (Stephens' type ; also Aberfoyle, *Carter*) ; England (New Forest, Theobald's types) ; France (Melun, *Debreuil ;* Bois de Lutterbach, Bois de Borne, Chalampe, *P. Lesne*) ; Germany (Lüben, Rados, Halle, *Loew ;* Bonn, *Schneider ;* Berlin, *Lichtwardt*) ; Denmark (Jutland, *Wesenberg-Lund*) ; Austria (Linz, Kahlenberg, Aigen, *Mik ;* Dornbach, *Handlirsch ;* Prater, *Pokorny ;* Styria, *Mann*) ; Hungary (Szóváta, *Csiki*) ; Siberia (Asinovo, 61° 25′ *Trybom*).

A long series collected by Dr. K. Kertész at Fuzine and Jasenak (Croatia) shows very little variation ; in all these the abdomen of both sexes has complete white basal segmental bands, and the dark-scaled area in the middle of the mesonotum is more extensive than usual, the specimens agreeing in this respect with many American examples of *A. aldrichi*, though not showing a pale median line dividing the dark area.

21. **Aëdes** (**Ochlerotatus**) **punctor** (Kirby) var. **meigenanus,** Dyar (fig. 7 g).

Culex punctor, Kirby, Fauna Boreali-Americana, Zool. Ins. p. 308 (1829).
Culicada (or *Ochlerotatus*) *nemorosus*, Theobald, de Meijere, Edwards, Lang (*nec* Meigen).
(?) *Culicada nemorosa* f. *haplolineata* and f. *alineata*, Schneider, Verh. Nat. Ver. Bonn, lxx, p. 37 (1913).
Aëdes punctor, Dyar, Insecutor Inscitiae, viii, p. 3 (1920), and ix, p. 71 (1921).
Aëdes meigenanus, Dyar, Insecutor Inscitiae, ix, p. 72 (1921).
Aëdes sylvae, Martini (*nec* Theobald), Über Stechmücken, p. 108 (1920).

This species is a variable one, and hence difficult to distinguish with certainty from its allies. The absence of a definite speckling of pale scales on the femora and tibiae, and the creamy tint of the abdominal bands—those on the last few segments being rather conspicuously narrowed in the middle—are, taken together, the best means of distinguishing the female. The male hypopygium is very distinct ; the large, prominent basal lobes and the short stem and strongly chitinised appendage of the claspette suggest that the species is really more nearly related to the *A. caspius* group than to the other members of the dark-legged group ; this supposition is to some extent borne out by the larval structure.

In the commonest type the mesonotum has brown or ochreous scales at the sides, with a broad longitudinal dark brown band in the middle ; this form is fairly distinct from other European species, though it might perhaps be confused with *A. sticticus* or *A. diantaeus* (*cf.* the distinctions of those species). Frequently, however, the dark central band of the mesonotum is either absent altogether or represented by two narrow bands, and such specimens are difficult to distinguish from *A. communis* or *A. pullatus*.

I have rejected the name *nemorosus* for this species, because there appear to be no examples of it so named in Meigen's collection in Paris, while there is a male of *A. communis* ; the name *nemorosus* has been used to cover so many species that there would be little advantage in retaining it. The present species is possibly Meigen's *C. sylvaticus*, but this is doubtful. While admitting that there are minute differences in larva and adult, as well as some distinction in breeding habits, between *A. punctor* and the European form, I cannot believe these are sufficient to justify

the maintenance of the two as distinct species. The European form should perhaps be known as *A. punctor* var. *meigenanus*. The hypopygium is identical in the two forms, and also in two or three other American forms which are regarded by Dyar as distinct species. The relationship of all these forms appears to require closer investigation.

It is quite possible that there may be more than one form in Europe, but the only evidence I have seen of this is provided by a male from Kuusamo, Finland, which has the hypopygium (and indeed the whole body) much more strongly chitinised than usual, and the hairs on the apical lobe rather longer. This may perhaps represent a distinct variety or species.

Distribution.—Apparently widely spread throughout northern Europe, and probably spreading across Siberia into Alaska and Canada. I have seen males from Britain; France; Belgium; Sweden (Stockholm, Småland, *Boheman;* Östergötland, *Wahlberg*); northern Lapland (*Boheman*); Finland (Kuusamo, Finnström, *Frey;* Kuustö, *Lundström;* Hattula, *L. v. Essen;* Karislojo, *J. Sahlberg;* Wiborg, *Pipping;* Jämsa, *Bergroth;* Tvarminno, *Levander*); Germany (Berlin, *Oldenberg, Stobbe;* Brocken, *Lichtwardt*); Hungary (Munkacs, *Ujhelyi*); also females, probably this species, from Austria (Hammern, *Mik*); Tyrol (Landro, *Mann*); Siberia (R. Ob, *Finsch;* Turuchansk, Yeniseisk, Inserovo, Antsiferovo and Nasimovo, all on R. Yenisei, *Trybom*).

22. **Aëdes (Ochlerotatus) parvulus,** sp. n. (fig. 8 f).

♂ Palpi all dark, long-haired, slightly shorter than the proboscis, proportions of joints, 55 : 26 : 19. Head-scales mixed in the middle, then grey, then a patch of blackish scales on each side; the broad lateral scales extend further up towards the middle of the head than usual; bristles black. Thorax dark brown; some white scales at the sides of the mesonotum; bristles rather dense. Abdomen black, the tergites with narrow straight basal bands of pure white scales. Legs almost all dark, the femora with only a few scattered pale scales and pale beneath. (Hind legs missing.) Length 4·5 mm.

Hypopygium: Lobes of ninth tergite each with about six short hairs. Basal lobe of side-piece prominent, rather pointed, with many long curved hairs but without a spine. Apical lobe very small, with a few short straight hairs. Claspette with the stem strongly curved; appendage with a broad membranous expansion commencing near the base.

♀ Similar to the male. Palpi about one-sixth as long as the proboscis. The hind tibiae have no pale lateral stripe. Length 3·5 mm.

A. parvulus has the appearance of a small, less hirsute race of *A. alpinus*, and perhaps it really is so, but the less strongly chitinised hypopygium, the absence of a spine on the basal lobes of the side-pieces, the slightly shorter male palpi, and the less speckled femora seem to be sufficient to distinguish it specifically.

Distribution.—Finland: Kittilä (♂ *F. Silén,* ♀ *U. Sahlberg*); type male and female in Helsingfors Museum; also several females, doubtfully conspecific, in Helsingfors and British Museums, from Karislojo (*J. Sahlberg*), Kusomen (*Hellén*) and Suomussalmi (*Hellén*); these last have mostly a fairly distinct pale hind tibial stripe, and the broad head-scales do not extend so far up as in the type.

23. **Aëdes (Ochlerotatus) communis** (De Geer) (fig. 7 j).

Culex communis, De Geer, Mémoires, vi, p. 316 (1776).
Culex nemorosus, Meigen, Syst. Beschr. i, p. 4 (1818).
(?) *Culex fasciatus*, Meigen, Klass. i, p. 4 (1804).
(?) *Culex leucomelas*, Meigen, Klass. i, p. 3 (1804).

(?) *Culex sylvaticus*, Meigen, Syst. Beschr. i, p. 6 (1818).
Aëdes obscurus, Meigen, Abbild. Zweifl. Ins. pl. ii, fig. 2 (1830).
Culex lazarensis, Felt & Young, Science, xx, p. 312 (1904).
Culicada nemorosa forma *diplolineata*, Schneider Verh. Nat. Ver. Bonn, lxx, p. 37 (1913).
(?) *Aëdes tahoensis*, Dyar, Insecutor Inscitiae, iv, p. 82 (1916).
(?) *Aëdes pionips*, Dyar, Insecutor Inscitiae, vii, p. 19 (1919).
Ochlerotatus palmeni, Edwards, Ent. Tidskr. p. 52 (1921).

This is one of a group of species which can only be satisfactorily distinguished by the structure of the male hypopygium. When this organ is mounted and examined under the high power of a binocular microscope, *A. communis* may be readily distinguished from other species by the two ridges at the base of the appendage of the claspette. These are best seen when the whole hypopygium is viewed from above; the small additional ridge is on the outer side of the appendage and at the base only. The long, strongly arched stem of the claspette and the form of the basal lobes seem to show that *A. communis* is more closely related to *A. cataphylla* and *A. salinellus* than to *A. pullatus* or *A. punctor*, though in coloration the first two species are more easily distinguished from *A. communis* on account of their speckled femora and tibiae. The indications of relationship afforded by the male hypopygium are also supported by the larval characters.

A. communis is evidently one of the most abundant woodland mosquitos of Europe, and is no doubt the species which has most frequently been identified as Meigen's *C. nemorosus*. This, together with the fact that a male of the species is included in Meigen's series of *C. nemorosus* in the Paris Museum, will definitely settle this name; although Meigen's description (brownish-yellow thorax, etc.) does not agree. De Geer's description of the adult and larva of *C. communis*, however, is quite sufficiently detailed for identification, and I have therefore adopted his name for the species. The disappearance of the name *nemorosus* from dipterological literature will be an advantage rather than otherwise, since it is now known that a number of species have been confused under this name.

I have examined the type of Meigen's *Aëdes obscurus*, which I received on loan through the kindness of M. Séguy. The hypopygium is apparently identical with that of *A. communis*, and the short palpi (if they were not merely broken) were therefore probably an individual abnormality similar to those which I have recorded as occurring in *A. punctor*.

In describing *C. nemorosus*, Meigen refers to his earlier description of *C. reptans* (Klass. i, p. 3, a doubtful identification of Linnaeus' *C. reptans*) as synonymous. In this earlier description, however, the tarsi are said to be white-ringed, so that the same species cannot have been referred to in both descriptions. The explanation probably is that Meigen intended to give a reference to his *C. leucomelas*, very briefly diagnosed immediately after *C. reptans*, with the remark, "Diese Art, die vielleicht nur eine Abändrung der vorigen ist, unterscheidet sich von derselben bloss durch die ganz schwarzen Füsse." This name *C. leucomelas* has been overlooked, and will unfortunately necessitate the renaming of a South American species.

Meigen's *C. sylvaticus* (*fasciatus*, 1804) is impossible to determine from the description, and I see no particular justification for Martini's suggestion that it is *Culex apicalis*; since the type does not exist it will be as well to accept Meigen's statement (Syst. Beschr. vi, p. 241) that it is only his *C. nemorosus*.

The American forms *A. lazarensis* and *A. tahoensis*, and probably also *A. pionips*, differ in such minute details that they can hardly be ranked as more than varieties of *A. communis*, but it is interesting to note that the hypopygium of the Alaskan *tahoensis* is the more nearly identical with European *communis* in regard to the exact position of the spine on the basal lobe of the side-piece, the only point in which Dyar has indicated distinctions between the American forms. I had intended to describe

a new species, *A. palmeni*, on account of some differences which I thought I perceived in the male hypopygium in two specimens from Finland. On a re-examination I failed to verify these differences, but meanwhile, unfortunately, I had published the name *palmeni* in my key to the Swedish species.

Distribution.—Europe, except west and south, and probably across Siberia to Alaska and Canada. I have examined male specimens from Denmark (*Wesenberg-Lund*); Sweden (Dalecarlia, Vesterbotten, Norrbotten, *Boheman*); Finland (Helsingfors, *J. Sahlberg;* Seitjaur, *Palmen*); France, Forêt de Marles, *Alluaud*); Germany (Berlin, *Lichtwardt*); Austria (Admont, Steiermark, *Strobl;* Richenau and Linz, *Mik;* Dornbach, *Handlirsch*).

I have also seen females, probably of this species, from Lappland and Siberia (Yeniseisk).

24. **Aëdes (Ochlerotatus) pullatus** (Coq.) var. **jugorum** (Villen.) (fig. 7 i).

Culex pullatus, Coquillett, Proc. Ent. Soc. Wash. vi, p. 168 (1904).
Culex jugorum, Villeneuve, Bull. Soc. Ent. France, p. 58 (1919); Séguy, Bull. Soc. Ent. France, p. 39, figs. (1921).
Aëdes metalepticus, Dyar, Insecutor Inscitiae, viii, p. 51 (1920).
Aëdes gallii, Martini, Über Stechmücken, p. 110 (1920).

This closely resembles *A. communis*, and it is almost impossible to distinguish the two satisfactorily, apart from the male hypopygium and the larva, which are very distinct. *A. pullatus* is somewhat smaller than *A. communis*, the integument is perhaps darker, and there are more numerous white scales on the mesonotum.

I have not seen the types, but an Italian male of *A. metalepticus* sent by Prof. Bezzi is practically identical in structure with an American male of *A. pullatus* in the British Museum; the distinctions given by Dyar must be due either to individual variation or to differences of mounting. The only differences observable in the Italian specimen were that the stem of the claspette was slightly stouter, slightly more angulated, and with a more distinct bristle arising from the angle; the main spine of the basal lobe was somewhat stouter, and the pale scales of the thorax whiter. These differences taken together may possibly indicate a varietal distinction.

Dyar suggested that *C. jugorum* might be the same as *A. metalepticus*, and this is almost certainly the case, but Séguy's figure of the hypopygium of a specimen (not the type) of *C. jugorum* shows a distinct apical hair-tuft on the side-piece, as in *A. intrudens*. The Verestorony examples that I have examined have an aggregation of hairs in this position, almost suggesting a tuft, and Séguy may have exaggerated the appearance of a tuft in his specimen, or the species may be somewhat variable. Both Séguy's and Kertész's specimens agree with Bezzi's except in this one point. As remarked by Villeneuve, there are long dense hairs arching over the upper (sternal) surface of the hypopygium, as in *A. rusticus*, *A. cataphylla*, and some others.

Distribution.—As yet imperfectly known; occurs in mountainous regions of Europe and North America, and therefore probably also of Central Asia. Recorded by Martini from Switzerland (*Galli-Valerio*), by Dyar from north Italy (*Bezzi*), and by Villeneuve from the Pyrenees (*Brolemann*). I have seen males from north Italy (Scais, *Bezzi*); Transylvania (Verestorony, *Kertész*); and the Balkans (Vermosa, 1200m., Greuze, *Penther*); also females, possibly of this species, from north Sweden (Kiruna, *Lichtwardt*).

25. **Aëdes (Ochlerotatus) intrudens,** Dyar (fig. 8 f).

Aëdes impiger, Howard, Dyar and Knab (*nec* Walker), Monogr. iv, p. 755 (1917).
Aëdes intrudens, Dyar, Insecutor Inscitiae, vii, p. 23 (1919).

I know of no satisfactory means of distinguishing the adults of this species from those of *A. pullatus* or *A. communis*, but the hypopygium is quite distinct, owing

to the dense tuft of hairs near the tip of the side-piece, projecting caudally from about the level of the apical lobe, though not actually from the lobe. The long hairs arching over the upper surface are not nearly so numerous as in *A. pullatus*. *A. diantaeus* also has a conspicuous hair-tuft, but in that species the tuft is situated about the middle of the side-piece and projects inwards. The claspette-stem in *A. intrudens* is angulated, with a projection arising from the angle, and a bristle on the projection.

Distribution.—Widely spread in Canada. I have seen only one European male, in the Berlin Museum, labelled 16.v.44, *H. Loew*. Dr. Enderlein informs me that Loew was most probably in the Posen district on this date.

Subgenus **Finlaya**, Theo.

Adult. Proboscis slender, longer than the front femora. Palpi short in the female; from one-half to nine-tenths as long as the proboscis in the male, the last two joints usually slightly thickened, moderately hairy and turned downwards. Head scales and ornamentation of thorax variable. Lower mesepimeral bristles absent. Male hypopygium with well developed claspettes, which bear a long and rather slender appendage; no apical or basal lobes to side-pieces; clasper and aedoeagus as in *Ochlerotatus*. Eighth segment of female only partly retractile, the sternite large and prominent in repose; cerci rather short. Front and middle claws of female toothed, the hind pair simple.

Larva. As in *Stegomyia*, with some exceptions.

Most if not all the members of this subgenus breed in tree-holes and similar situations or in rock pools. The species are most numerous in the Oriental region, but they are found in practically all parts of the world, except the polar regions. Owing no doubt to their restricted breeding-habits, there is a strong tendency in this subgenus to the production of local species, and comparatively few have a wide distribution.

Adults.

1. Tarsi (at least hind pair) with whitish rings 2
   Tarsi all dark 4
2. Tarsal rings extending on to apices of joints; thorax not distinctly lined *togoi* (Theo.).
   Tarsal rings at bases of joints only; thorax conspicuously lined 3
3. First three joints of hind tarsi ringed at base, last two all dark *japonicus* (Theo.).
   All joints of hind tarsi ringed at base .. .. .. *koreicus*, Edw.
4. Head scales almost all broad and flat; a large (sometimes divided) silvery-white area on the front of the mesonotum .. *niveus* (Ludlow).
   Head scales narrow except at the sides; mesonotum otherwise 5
5. Mesonotum with narrow lines of yellowish scales, sides not broadly whitish .. .. *eatoni* (Edw.).
   Sides of mesonotum broadly whitish scaled 6
6. Scales of scutellum mostly or all narrow and ochreous .. *geniculatus* (Oliv.).
   Scales of scutellum all broad, flat and white .. .. *echinus*, Edw.

Male Hypopygia.

1. Stem of claspette extremely short, knob-like.. .. .. *togoi* (Theo.).
   Stem of claspette about as long as the appendage 2
2. Side-piece with a tuft of large scales on the upper side .. *niveus* (Ludlow).
   Side-piece with small scales on the outer side only 3
3. Side-piece with very long and rather dense hair, as long as the side-piece itself, on the upper flap .. .. *eatoni* (Edw.).
   Hair on side-piece shorter, only about half as long as the side-piece .. 4

4. Lobes of ninth tergite with 6–8 fine hairs .. *japonicus* (Theo.) ; *koreicus*, Edw.
Lobes of ninth tergite with 2–4 stouter hairs .. *geniculatus* (Oliv.).

Since most of the larvae are unknown, a table cannot be given.

26. **Aëdes (Finlaya) togoi** (Theobald).

Culicelsa togoi, Theobald, Mon. Cul. iv, p. 379 (1907).

This is very distinct from the other Palaearctic species of the subgenus, both in the tarsal markings and in the male hypopygium, which shows the following characters :—Side-pieces a little over twice as long as their depth at the base ; upper flap much expanded basally, its inner margin with a dense row of long, slightly flattened bristles or bristle-like scales, extending the whole length except on the expanded basal portion ; the lower flap has an aggregation of hairs at the base, but no definite basal lobe. Claspers moderately long, nearly cylindrical, tapering ; terminal spine not very long. Claspettes with the stem extraordinarily short, reduced to a mere knob ; appendage sickle-shaped, slender, not expanded in the middle. Lobes of ninth tergite small, with about 6–8 moderately long hairs.

The male palpi are about three-quarters as long as the proboscis, nearly straight and slightly hairy.

The larva is undescribed (unless recently by Yamada) ; Dr. Lamborn found them in granite basins in cemeteries.

Distribution.—Japan (Osaka, *Theobald ;* Tokio, *S. Yamada, Harmand ;* Yokohama and Kobe, *Lamborn*) ; eastern Siberia (Vladivostok, *per Dr. C. S. Ludlow*).

27. **Aëdes (Finlaya) japonicus** (Theobald).

Culex japonicus, Theobald, Mon. Cul. i, p. 385 (1901).

Apart from the tarsal characters, which are diagnostic, this species is noteworthy for the fine yellowish lines on the mesonotum ; similar lines are found in *A. koreicus* and *A. eatoni*. The male palpi are slightly shorter than the proboscis, slender, the last two joints somewhat upturned, and with rather scanty hairs, thus approaching very nearly to the type of palpi found in *Stegomyia*. The male hypopygium is extremely similar to that of *A. geniculatus*. Theobald suggested that this might possibly be the same as *A. aureostriatus* (Dol.), but this is unlikely.

The larva is undescribed, unless recently by Yamada ; Dr. Lamborn found a few in similar situations to those in which he took *A. togoi*.

Distribution.—Japan (Tokio, *Theobald, Yamada ;* Kofou, *L. Drouard de Lezey ;* Chuzenji, *E. Gallois ;* Nagasaki, *Lamborn*).

28. **Aëdes (Finlaya) koreicus,** Edw.

Ochlerotatus (*Finlaya*) *koreicus*, Edwards, Bull. Ent. Res. vii, p. 212 (1917).

This should probably be ranked as a variety of *A. japonicus*, from which it differs in little else than in having narrow white rings at the bases of the last two hind tarsal joints. The palpi of the type male are perhaps slightly less hairy than in *A. japonicus*.

The larva is unknown.

Distribution.—Korea (*Dr. R. G. Mills*).

29. **Aëdes (Finlaya) niveus** (Ludlow).

Stegomyia nivea, Ludlow in Theobald, Mon. Cul. iii, p. 139 (1903).
Stegomyia pseudonivea, Theobald, Ann. Mus. Nat. Hung. iii, p. 75 (1905).
Stegomyia albolateralis, Theobald, Rec. Ind. Mus. ii, p. 289 (1908).

In typical examples of *A. niveus* the silvery area on the scutum forms a solid patch, but in some specimens (generally females) it is divided more or less completely by a dark median stripe, which may even reach the front margin. The

specimens with this dark stripe (such as the Japanese examples recorded below) may represent a distinct species or variety (*albolateralis*, Theo.), but in view of Leicester's remarks on the variability of the species I doubt if this is so. Unfortunately, I did not examine the hypopygium of the Japanese male. A male from the Andaman Islands shows the following characters :—Side-pieces about twice as long as their depth (or three times as long as their width) at the base, tapering, densely scaly on their outer and under sides, finely hairy on the inner side, some long hairs at the base beneath ; a dense row or tuft of very long and broad scales on the upper (sternal) side, not reaching the base. Claspers short, with a very long terminal spine which is quite two-thirds as long as the clasper itself. Lobes of ninth tergite with about four very long bristles. Claspettes with the appendage moderately expanded in the middle, about equalling the stem in length. The male palpi are of practically the same length as the proboscis, the last two joints turned downwards and bearing long hairs.

If Eichwald's *Culex niveus* is an *Aëdes*, the name is ineligible for this species, and *pseudoniveus* should be used instead, but in view of the uncertainty there is perhaps no necessity to make the change.

The larvae are not yet described, though Leicester records finding them in cut bamboos.

Distribution.—A widely-spread Oriental species extending into Japan (Tokio, *S. Yamada ;* 1 ♂ 1 ♀ in coll. *M. Koidzumi*).

30. **Aëdes** (**Finlaya**) **eatoni** (Edw.).

Ochlerotatus eatoni, Edwards, Bull. Ent. Res. vi, p. 358 (1916).

Apart from the very different thoracic markings, this species differs from *A. geniculatus* in the coloration of the hind femora, which are black above for their whole length, instead of entirely white on the basal half. The female and larva remain unknown, the description being based on a single male, the palpi of which are only about two-thirds as long as the proboscis.

Distribution.—Madeira Island (*Eaton*).

31. **Aëdes** (**Finlaya**) **geniculatus** (Oliv.) (figs. 1 b, 5 g, 10 a).

Culex geniculatus, Olivier, Encycl. Méth. Hist. Nat. Ins. vi, p. 134 (1791).
(?) *Culex lateralis*, Meigen, Syst. Beschr. i, p. 5 (1818) et auct.
Culex ornatus, Meigen, Syst. Beschr. 1, p. 5 (1818).
Culex guttatus, Curtis, Brit. Ent. p. 537 (1834).
Culex fusculus, Zetterstedt, Dipt. Scand. ix, p. 3459 (1850).
Culex albopunctatus, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).

The shining white, almost silvery knee-spots, and the coloration of the hind femora will distinguish even somewhat rubbed adults of this species from any member of the subgenus *Ochlerotatus*. Fresh specimens are obviously distinct by their thoracic markings. From the allied *A. echinus* this species differs mainly in the narrower scutellar scales ; but even this is not absolutely diagnostic, as I have seen a male from the south of France which is certainly only *A. geniculatus*, but which has some small flat scales on the scutellum. The larva, however, is very different from that of *A. echinus*, and as it is the only other species of the genus which is found in tree-holes in Europe, no confusion with any other species is likely.

As I have previously stated (Ent. Mo. Mag. 1912, p. 277), I do not think there can be any doubt that Olivier's name should apply to this species, and that Theobald was in error in using it for *Culex hortensis*. I now believe that the female which Meigen originally described as *C. ornatus* must have been this species, although the male which he described at a later date must have been something else, as he refers to the white marks on the palpi. Van der Wulp, Verrall, Galli-Valerio

and others who identified *C. ornatus* as this species were therefore probably right. Meigen's *C. lateralis* may also be the same, as supposed by Theobald, but the type being lost it is impossible now to say whether it was this species or *A. sticticus*. Mr. J. E. Collin has kindly examined for me the two males of *C. fusculus* in Zetterstedt's collection at Lund, and from his notes and accompanying sketch of the claspette there can be no doubt that *C. fusculus* is *A. geniculatus*. Zetterstedt must also have included with these males rubbed females of other species, as one which was sent me by Dr. Bengtsson in 1912 was an *Ochlerotatus* near *O. cataphylla*.

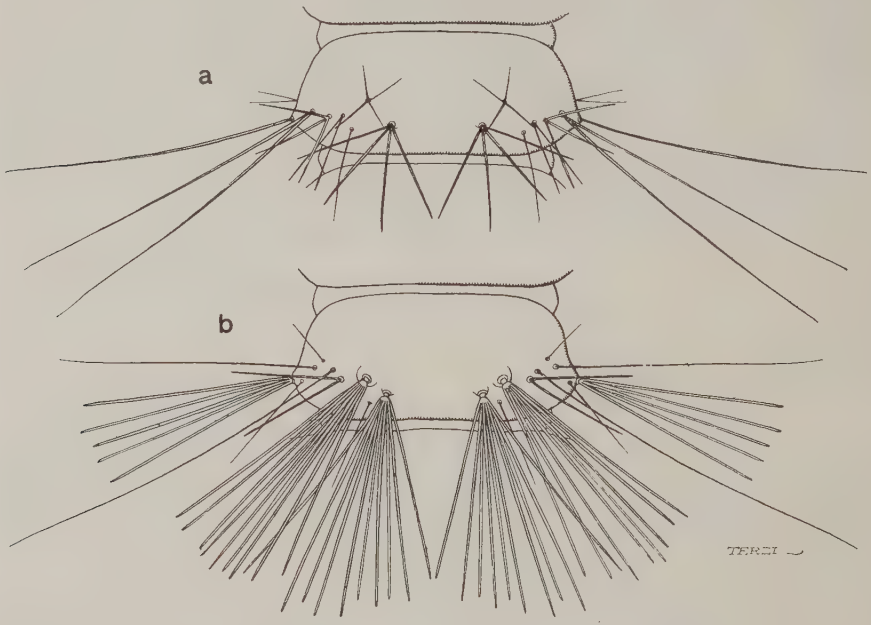

Fig. 10. First abdominal segment of larva of (a) *Aëdes geniculatus* and (b) *Aëdes echinus*, showing the remarkable difference in the development of the hairs.

Distribution.—Throughout Europe from France to Galicia and from south Sweden to Macedonia, wherever there are deciduous trees, such as beech, sycamore, plane, horse-chestnut, sweet chestnut, etc., in sufficient numbers. It occurs also in Corsica (*Yerbury, Séguy*) and in Asia Minor (Brussa, *Mann*). It is not yet known from Siberia or North Africa, though its known range will no doubt be extended by future observations. The most northerly record I have is Scania, Sweden (*Boheman*). Its absence from the far north may be accounted for by the fact that coniferous trees, also birches and willows, do not readily form rot-holes that will contain water. Its apparent absence from Scotland and Ireland is not so easy to explain. The North American representative (*A. triseriatus*, Say) is specifically distinct.

32. **Aëdes (Finlaya) echinus** (Edw.) (figs. 6 a, 10 b, 11).

Ochlerotatus (*Finlaya*) *echinus*, Edwards, Bull. Ent. Res. x, p 133 (1920).

The adult is very similar to *A. geniculatus*, apart from the two points mentioned in the key, but the larva is strikingly different, chiefly on account of the remarkable development of the hair-tufts on the thorax and abdomen. These appear to correspond rather closely in number and position with those of *A. geniculatus*, but the component hairs are more numerous, distinctly plumose, somewhat longer, and much stouter, giving the insect a very urchin-like appearance (whence the specific

name). Fig. 10 illustrates well the difference in vestiture of the first abdominal segment in the two species; the following segments in both have the hairs longer. (In the case of *A. echinus* both the skins preserved by Capt. Waterston are much distorted, and careful reconstruction was necessary.) The larva of *A. echinus* also differs from that of *A. geniculatus* in the distinctly longer antennae, which are much more extensively pale towards the tip, in the much more numerous pecten teeth, which are in a straighter row, in the somewhat smaller siphon and somewhat larger comb teeth, as well as in some other details, perhaps not constant.

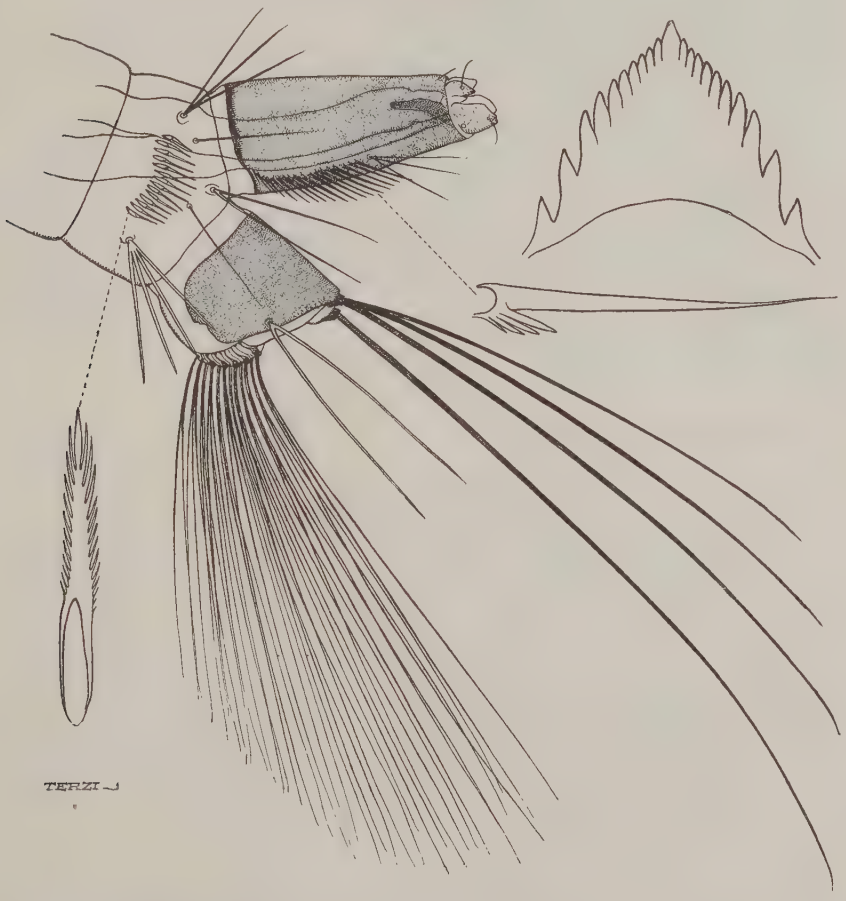

Fig. 11. *Aëdes echinus*, Edw., end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

The pupa differs from that of *A. geniculatus* in having the paddles more strongly emarginate and the terminal hair placed at some distance outside the tip of the midrib.

Distribution.—Macedonia (Stavros, *Waterston;* reared from larvae in hole in plane tree; many adults of *A. geniculatus* also found in the same locality); Morocco (Fez, *Fowler*); Algeria (*Sergent*).

Subgenus **Ecculex,** Felt.

Adult.—As in *Ochlerotatus,* but the male palpi are usually no longer than the proboscis ; the vertex and the scutellum in many species are covered with flat scales ; lower mesepimeral hairs are usually absent ; the male hypopygium has no distinct claspettes, these being represented by hairy basal lobes ; while, on the other hand, the claspers are highly modified in most species, and even in the simple forms are distinguished by having the spine inserted before the tip. The aedoeagus is quite different from that of *Ochlerotatus,* but almost identical with that of *Aëdes.* The hind claws are usually simple.

Larva.—Practically as in *Ochlerotatus,* but the pecten usually has detached teeth outwardly, which in *Ochlerotatus* is rarely the case, and the siphonal tuft is usually distinctly beyond the middle.

In *E. vexans* the frontal hairs are situated one in front of the other, as in *Ochlerotatus,* but in the rather numerous Ethiopian species of which the larvae are known the anterior pair is placed outside the posterior, as in *Culex* and *Aëdes* (*s. str.*).

It is only with reluctance, in deference to the opinion of Dyar, that I recognise this as a distinct subgenus, as it is almost impossible to define apart from the characters of the male hypopygium. However, there is no doubt that it is a natural group, representing a distinct line of evolution in which the clasper has undergone specialisation instead of the claspette. The separation is confirmed by present-day distribution, the species being numerous in the Oriental and Ethiopian regions, only a single one extending into the Palaearctic and Nearctic, while none are found in the Neotropical, and only one or two in north Australia.

33. **Aëdes** (**Ecculex**) **vexans** (Mg.).

Culex vexans, Meigen, Syst. Beschr. vi, p. 241 (1830).
(?) *Culex parvus,* Macquart, Suites à Buffon, i, p. 36 (1834).
Culex articulatus, Rondani, Bull. Soc. Ent. Ital. iv, p. 30 (1872).
Culex malariae, Grassi, Atti Acc. Lincei, vii, p. 168 (1898) ; Noé, Bull. Soc. Ent. Ital. xxxi, p. 244 (1899).
(?) *Culex arabiensis,* Patton (adult, not larva), J. Bombay Nat. Hist. Soc. xvi, p. 633 (1905).

Apart from the characters of the male hypopygium and the somewhat shorter male palpi, this species is not easy to distinguish from the *annulipes* group of the subgenus *Ochlerotatus,* especially small specimens of *A. maculatus.* The structural and scale characters are the same, except that the hind claws are often (not always) simple ; in both the lower mesepimeral bristles are absent. We have therefore, in the case of the female, to rely mainly on coloration for the determination of this species, the most constant feature being the median emargination of the pale abdominal bands. The white tarsal rings are always narrow, but rather variable ; in large specimens they are sometimes not much narrower than those of the narrowest-banded specimens of *A. maculatus ;* while in the other examples (generally small ones) they are often so narrow as to be visible only under a lens. The head markings (the uppermost of the flat scales at the sides of the head being black, the rest pale) are of a type very rarely met with in *Ochlerotatus,* but common in *Ecculex, Stegomyia* and *Finlaya. E. vexans* differs from the great majority of species of the subgenus in having no flat scales either on the vertex or on the scutellum, its resemblance to the subgenus *Ochlerotatus* being thus increased.

Two varieties occur within the Palaearctic region : the typical form, in which the abdomen has only the emarginate white bands on a dark ground ; and the variety *nipponii,* Theobald, in which the abdominal segments have, in addition to the bands, a median whitish patch.

The species is so abundant in many parts of Europe as to constitute a serious plague; so much so that, according to Eckstein and others, agricultural work in some districts has to be carried on by night and cattle stalled during the day, owing to the attacks which *A. vexans* makes by day on the men and cattle.

The larva occurs characteristically in flooded meadows, and several generations are passed through in the year. There is very little difference between the larva and those of some species of *Ochlerotatus* which have detached teeth at the end of the pecten, even the distinctions given in the key being somewhat doubtful. According to the figure and description in Howard, Dyar and Knab's monograph (where the species is named *A. sylvestris*, Theo.), the siphonal tuft is situated in the middle, though according to Schneider and Martini it is placed well beyond the middle. The only larvae I have seen are from Ceylon, and these agree entirely with Martini's description; I suspect therefore that the American description may be in error, as there is certainly no difference in the adults.

Distribution.—Apart from the domestic species (*Culex pipiens*, *C. fatigans* and *Aëdes argenteus*), this is the most widely spread of all mosquitos, occurring practically throughout the Palaearctic, Oriental and Nearctic regions. Possibly it may have had its origin in tropical Africa, where there are a number of related forms, but if so its apparent absence from that region at the present time is remarkable. It is common throughout central Europe, perhaps less so in the south, and certainly rare in the north. Some fresh records are: Sweden (Oeland I., *Boheman*); Finland (Helsingfors, *Frey*; Tvarminno, *Levander*); Italy (Susa, Sondrio, Torino, Macerata, Chivasso, *Bezzi*); Asia Minor (Konia, *Naday*); Transcaspia (Tashkent, Aschabad, *C. Ahnger*); Ussuri (Spasskaja, *Wuorentaus*); Persia (Enzeli, *Buxton*); Korea (*Yamada*); Aden (*Kazan Chand, per Capt. P. J. Barraud*).

The variety *nipponii* occurs in China and Japan, also the Amur region (Ussuri, Spasskaja, *Wuorentaus*).

Subgenus **Aëdes,** Mg.

Adult. Proboscis (in the Palaearctic species) about equal in length to the front femora, or slightly shorter. Palpi very short in both sexes. Antennae of the male with the hair-whorls evenly spread all round the joints. Vertex with broad flat scales, leaving only a small patch of narrow ones on the nape. Lower mesepimeral bristles absent. Male hypopygium with the claspers deeply bifid, without terminal claw, inserted before the tip of the side-piece; the latter with small hairy basal lobes. Aedoeagus with the parameres indistinct, almost membranous, the mesosome chitinised in two lateral halves, which are split into rather numerous small spines; one very much larger spine is apically directed. Female cerci moderately elongate; eighth segment rather large. Front and middle claws of female toothed.

Larva. Antennae rather long, with numerous spinules and well-developed tuft. Frontal hairs not one in front of the other, as in *Ochlerotatus*, but almost side by side (in Lang's terminology, the three post-antennal hairs are almost in one line, the middle one not displaced). The median anterior thoracic tufts are absent.

34. **Aëdes (Aëdes) cinereus,** Mg.

Aëdes cinereus, Meigen, Syst. Beschr. i, p. 13 (1818).
Aëdes rufus, Gimmerthal, Bull. Soc. Imp. Nat. Moscou, xviii, p. 295 (1845).
Aëdes leucopygus, Eysell, Abh. Ver. Naturk. Kassel, xlviii, p. 285 (1903).
Culex nigritulus, Zetterstedt, Dipt. Scand. ix, p. 3459 (1850).
Aëdes fuscus, Osten-Sacken, Bull. U.S. Geol. Surv. iii, p. 191 (1877).
? *Culex ciliaris*, Linnaeus, Syst. Nat. Ed. xii, i, p. 1002 (1767).

This species need not be confused with any other in the Palaearctic fauna. The mostly flat-scaled head, extremely short palpi of the male, reddish, unmarked thorax,

and dark-scaled dorsum of the abdomen of the female, should make it quite unmistakeable. So far as European specimens are concerned there is little variation, though it should be noted that the thorax of the male is always much darker than that of the female, usually quite black.

The larva does not differ in any very striking manner from those of the subgenera *Ochlerotatus* and *Ecculex*; the main points have already been noted. The early stages are spent usually in flooded meadows and large marshes, but the species is also found in woods. It is commonly associated with *A. vexans*.

Distribution.—Throughout Europe, and extending across Siberia to North America, where it has a wide distribution. The following are some new records:—Italy (Sondrio, *Bezzi*); Finland (various localities and collectors); Siberia (Yeniseisk, 58° 20′, and Turuchansk, 65° 55′, *Trybom;* Omsk, *Granö*).

Subgenus **Stegomyia,** Theo.

Adult. Proboscis moderately slender, but stouter than in *Ochlerotatus*, scarcely as long as the rather short front femora. Palpi short in the female, normally longer than the proboscis in the male, the last two joints slender, upturned, with very few hairs. Vertex with broad flat scales, few or no narrow ones on the nape. Thorax usually with conspicuous and well-defined ornamentation. Lower mesepimeral bristles absent. Male hypopygium usually without claspettes, unless these are represented by hairy basal lobes; no apical lobes; clasper with distinct terminal spine. Aedoeagus divided into two more or less brush-like halves. Eighth segment of female abdomen rather large, but distinctly retractile, the sternite not very prominent in repose; cerci rather short. Front and middle claws of the female either toothed or not.

Larva. Antennae short, with single hair and without spicules on shaft. Frontal hairs single. Abdomen with or without numerous stellate tufts on dorsal surface; the eighth segment with a definite comb of teeth set in a single row. Siphon not much more than twice as long as broad; hair-tuft well developed and situated about the middle.

The larvae of many African species live in tree-holes, leaf-axils, etc., and these species show a much greater development of the abdominal hair-tufts than is seen in the Palaearctic species.

Adults.

1. Mesonotum with a median silvery-white line 2
   Mesonotum without such line 3
2. Female claws simple (Japan) .. .. *albopictus* (Skuse).
   Female claws toothed (Crete) .. .. *cretinus*, sp. n.
3. Mesonotum with a lyre-shaped silvery-white mark; tibiae dark except at tip .. .. *argenteus* (Poiret).
   Mesonotum with four distinct white dots; tibiae ringed with white a little beyond the middle .. .. *vittatus* (Bigot).

Male Hypopygia.

1. Clasper modified, swollen and hairy apically, the spine long and curved and placed far before the tip .. .. *vittatus* (Bigot).
   Clasper normal; spine shorter, straight, and terminal 2
2. Clasper shorter, narrowed at the tip, side-piece with a large, densely bristly area .. .. *argenteus* (Poiret).
   Clasper longer, slightly swollen at the tip, side-piece with a large, hairy basal lobe .. .. *albopictus* (Skuse).

35. **Aëdes (Stegomyia) albopictus** (Skuse).

Culex albopictus, Skuse, Ind. Mus. Notes iii, p. 20 (1895).
Stegomyia scutellaris, Theobald (*nec* Walker), Mon. Cul. i, p. 298 (1901).

This is the only species of *Aëdes* in the Palaearctic region in which the front and middle claws of the female are not toothed; it cannot however be removed from the genus, or even from the subgenus *Stegomyia*, with which it agrees in all other respects. The silvery line down the middle of the mesonotum will at once differentiate it from all other mosquitos in the region except *A. cretinus*, its Mediterranean representative.

The larva has been described and figured by Banks (Phil. J. Sci. A, iii, 1908, p. 246) but he omits to notice the structural difference from *A. argenteus* in the shape of the comb-teeth.

Distribution.—A common semi-domestic species throughout the Oriental region, occurring in Japan in the neighbourhood of Tokio (*Yamada*); Mt. Takao, near Hachioji and Kofou (Paris Museum); Yokohama and Kobe, also Shanghai (*Lamborn*). It occurs also in Madagascar and Réunion.

36. **Aëdes (Stegomyia) cretinus,** sp. n.

Closely allied to *A. albopictus*, Skuse, but differs as follows:—A pair of small round spots of white scales in the middle of the mesonotum, a little in front of the wing-roots level with the posterior end of the central white stripe. Abdomen with very distinct white basal bands on segments 2–7, somewhat narrowed in the middle. Fourth hind tarsal joint darkened only at the extreme tip. Front and middle claws toothed. As in *A. albopictus*, the front and middle femora have a narrow line of white scales towards the base anteriorly, but no median white spot.

A single female in Herr Lichtwardt's collection, labelled "Creta. v. O. *Culex calopus*, Mg." Since, apart from the toothed claws, there are slight differences from both *A. albopictus*, Skuse, of the Oriental region, and *A. unilineatus*, Theo., of Africa and the Punjab, it is more likely that we are dealing with a distinct Mediterranean representative of *A. albopictus* than that there has been any error in labelling.

A second female is in the Buda-Pest Museum from Amari, Crete, 4. vi. 1906 (Biró); the abdomen and claws agree with the type, but the mesonotum is rubbed and the hind tarsi missing.

37. **Aëdes (Stegomyia) argenteus** (Poiret) (*Stegomyia fasciata*).

Culex argenteus, Poiret, Journ. de Phys. xxx, p. 245 (1787).
Culex fasciatus, Fabricius, Syst. Antl. p. 36 (1805).
Culex calopus, Meigen, Syst. Beschr. i, p. 3 (1818).
Culex konoupi, Brullé, Exp. Sci. de Morée, Zool. iii, p. 289 (1836).
(?) *Culex niveus*, Eichwald, Reise Casp. Kauk. ii, p. 183 (1837).
Culex elegans, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 95 (1889).
Culex albopalposus, Becker, Mitt. Zool. Mus. Berlin, iv, p. 80 (1908).
Culex angustealatus, Becker, Mitt. Zool. Mus. Berlin, iv, p. 79 (1908).
? *Culex aegypti*, Linnaeus, Hasselquist's Reise nach Palestina, p. 470 (1762).

The yellow fever mosquito is widely spread, though apparently nowhere very abundant, in the warmer parts of the Palaearctic region. It occurs on the Atlantic islands, in Portugal, and all round the Mediterranean coasts. In the eastern Mediterranean it is by no means confined to the coasts, since Barraud has found it to be common at Aleppo. Further east it is known from Mesopotamia, Persia, and Japan.

Eichwald says of *Culex niveus*, which he records from Tiflis and Baku, "in unzähliger Menge abends in den Zimmern bemerkt werden." This, together with his "thorax nigro alboque varius, alba pube obsitus" and "pedibus nigro canoque variis," seems to suggest *Aëdes argenteus*, but other parts of the description("alis

niveo-albis, corpore ex dimidio fere brevioribus," and "pedibus anticis in apice utrinque fasciculo pilorum ornatis") will not apply to this or any other known mosquito.

It is quite possible that Dyar may be right in identifying *C. aegypti* with this species. Certainly it seems to be some *Stegomyia*, and *A. argenteus* is the only member of the genus now known to occur in Egypt, but there are one or two points in the description which quite definitely do not agree; I have therefore not adopted the name.

38. **Aëdes (Stegomyia) vittatus** (Bigot).

Culex vittatus, Bigot, Ann. Soc. Ent. France, (4) i, p. 327 (1861).
Stegomyia sugens, Theobald, Mon. Cul. i, p. 300 (1901).
Culex sugens, Wiedemann, Aussereurop. zweifl. Ins. i, p. 545 (1828).

The white dots on the mesonotum, together with the white-ringed tibiae and tarsi, make this species an extremely easy one to recognise. The pre-apical spine of the male clasper, and the position of the siphonal tuft of the larva well beyond the middle, suggest that the species may have more in common with the subgenus *Ecculex* than with other species of *Stegomyia*, in spite of the spineless larval antennae and the slender, bare, upturned male palpi. The species affords a good illustration of the difficulty of drawing any hard and fast line between the subgenera of *Aëdes*, and confirms the inclusion of all of them in one comprehensive genus.

The larva has been recorded as occurring in rock pools.

Distribution.—Corsica (*Bigot*). Also widely distributed in the Ethiopian and Oriental regions, occurring as far south as Ceylon. It is remarkable that so conspicuous a species has not been found in the Mediterranean region since Bigot's time.

Genus **Armigeres,** Theobald.

This genus is evidently closely allied to *Aëdes* (especially the subgenera *Aëdes* and *Stegomyia*), so much so that scarcely any tangible differences can be discovered in the adults. The proboscis is rather short (not longer than the front femora) and is slightly but distinctly stouter throughout than in *Aëdes*; also the tip is slightly but distinctly curved downwards (at least in dry specimens), which is very seldom the case in *Aëdes*. In the allied Oriental genus or subgenus *Leicesteria* the mesonotum is somewhat produced over the head, and this tendency is slightly indicated also in the typical subgenus *Armigeres*. The structure of the eggs and manner of oviposition in *Armigeres* is similar to that of *Aëdes*; but *Leicesteria flava*, according to Strickland, has peculiar egg-laying habits. The male clasper has numerous spines, generally placed in a row (4–10 in *Leicesteria*, 15–20 in *Armigeres*). Another small point of distinction from *Aëdes* is that the middle claws of the male are apparently always equal and simple.

The main reason for keeping *Armigeres* distinct from *Aëdes* is the structure of the larval siphon, which has only a minute and often scarcely distinguishable hair-tuft, and no trace of a pecten. This latter point constitutes such a sharp difference from *Aëdes* that the separation from that genus may be justified, in spite of the feeble characterization of the adults. The anal gills are of large size and rounded apically.

The genus is endemic in the Oriental region, a single species extending into Japan and thus claiming our attention in this paper.

Armigeres obturbans (Walker).

Culex obturbans, Walker, Proc. Linn. Soc. London, iv, p. 91 (1860).
Culex subalbatus, Coquillett, Proc. U.S. Nat. Mus. xxi, p. 302 (1898).

Like the other species of the genus, this is a dark-coloured insect, with entirely dark tarsi and mainly white venter, and with flat scales, mostly dark, covering the head and scutellum. It differs from all its congeners in having a distinct if narrow band of black scales at the apex of each abdominal sternite. The male palpi resemble those of *Stegomyia,* but are entirely dark. I am indebted to Dr. H. G. Dyar for information as to the identity of Coquillett's type.

The larvae live in bamboo stems, and have been described by Banks (Phil. J. Sci., A. iii, p. 240, 1908). They have remarkably large, sausage-shaped anal gills, which enable them to remain long periods at the bottom.

Distribution.—Japan (Kofou, *L. Drouard de Lezey ;* Kouy-Tchéou, *Fortunat ;* Hakone, *E. Gallois ;* Tokio, *Yamada*) ; also throughout the Oriental region, and extending into Celebes, New Guinea and North Australia.

Genus **Lutzia,** Theobald.

Owing to the highly modified larval mouth-parts and antennae, and the peculiar structure of the siphon and anal segment, it was long ago proposed by Christophers to separate the Old World species of this genus from *Culex* as a distinct genus (*Jamesia*) ; the same characters were used by Dyar and Knab in separating the New World *Lutzia* from *Culex.* In revising the African Culicidae in 1912 I did not accept this separation, owing to the apparent structural identity of the adults. I now find, however, that an excellent diagnostic character exists in the numerous lower mesepimeral bristles of *Lutzia,* and I therefore propose to revive this name. There is no real difference between the Old World and New World forms, and I consider Dyar's separation of *Jamesia* and *Lutzia* on a small detail of aedoeagal structure to be quite unjustifiable. The Old World species are all very similar, their separation resting on small differences of colour and venation.

Lutzia vorax, sp. n. (fig. 5 d).

Penultimate joint of male palpi with the integument and the hairs dark except at the extreme tip. Abdominal tergites in both sexes all with rather narrow but distinct apical pale ochreous bands. Lobes of mesosome of male aedoeagus enlarged beneath a little beyond the middle, the enlargement with some minute teeth ; lobe of side-piece with three strong spines only. The whole of the outer side of the hind femora has the light and dark scales about evenly mixed. Cross-veins either in a straight line, or else m-cu (posterior) placed beyond r–m (mid).

L. concolor (R.–D.), Theo., the commonest form in the Oriental region, differs in having the last few abdominal segments entirely yellow-scaled, the yellow bands on the anterior segments narrower ; the lobes of the mesosome are not enlarged beneath ; the lobe of the side-piece usually has a fourth spine more or less developed, separate from the other three ; the outer side of the hind femora is entirely pale at the base, from which a more or less definite pale line runs almost to the apex ; and the cross-vein m–cu is placed at least slightly before r–m.

L. halifaxi (Theo.), known from the Malayan region and Queensland, has the hypopygium almost identical with that of *L. vorax,* the enlargement of the mesosomal lobes perhaps more prominent and practically in the middle ; it differs in having the integument and hairs on the apical half or more of the penultimate joint of the male palpi paler than the basal part, and in having few or no pale scales on the apices of the abdominal tergites ; the hind femora are as in *L. vorax,* but darker ; the cross-veins, on the other hand, are placed as in *L. concolor.*

Dr. Lamborn found the larvae in old cess-pits preying upon *Culex fatigans.*

Distribution.—Japan (Tokio, *Yamada ;* a series presented to the British Museum in 1916, determined at the time as *Culex concolor;* the type of the new species is one of the three males in this series ; also Karuizawa, *Cornford,* and Nagasaki,

Lamborn). North India (Punjab, *Barrow ;* female only). Probably widely distributed in the Oriental region, but confused with the two species above mentioned and with the Ethiopian *L. tigripes.*

Genus **Culex,** L.

This genus, I find, is sharply distinguished from almost all other mosquitos by the possession of distinct pulvilli. It is remarkable that the presence of these structures has been overlooked for so long ; Howard, Dyar and Knab even state positively that they are absent throughout the family ; these and other writers must either have omitted to study *Culex* closely, or else have used an insufficient magnification. I have examined a large number of species of this genus, and find pulvilli present in all ; they do not vary much in size, but are naturally more easily detected in the larger species. Figs. 5 d and 5 e (made with the aid of a camera lucida) show clearly the different appearance under a sufficiently high power between a hairy empodium and a pair of true pulvilli. In the front and middle tarsi of the male the pulvilli, like the claws, are elongated, and therefore less noticeable ; they may be seen, however, on the hind tarsi as well as on all the feet of the female. The only other mosquitos which possess pulvilli are the genera which on other grounds have already been regarded as close allies of *Culex : Culiciomyia, Lophoceratomyia, Micraëdes Carrollia, Lutzia,* and *Deinocerites* (including *Dinomimetes*). The first three or four of these should not be regarded as more than subgenera of *Culex,* though the last two may be treated as distinct genera.

The following characters are also common to most if not all species of *Culex* ; some of these will further help to distinguish the members of this genus from *Aëdes* : Eyes very narrowly separated or even touching for a considerable length above the antennae. Proboscis not or scarcely longer than the front femora. Male palpi when long always slender, with the last two joints upturned. Male antennae always plumose, with the hairs spreading out evenly all round. Spiracular and post-spiracular bristles absent. Usually only one lower mesepimeral bristle or none ; very rarely two or three. Female abdomen blunt-ended, the cerci short and broad, eighth segment not at all retractile. Male hypopygium without claspettes or basal lobes to the side-pieces, but with subapical lobes bearing modified bristles. Tenth sternites ending in a tuft or comb of spines. Mesosome a paired structure with pointed processes. Claspers articulating in a more or less vertical plane. First joint of hind tarsus as long as the tibia or slightly longer. Female claws always simple. Wings with distinct microtrichia on the membrane ; cell R_2 markedly longer than its stalk in the female ; vein A_n ending much beyond the level of the base of R_3.

Larva.—Antennae with a distinct hair-tuft, which is generally well beyond the middle, the part of the antenna beyond the tuft usually rather suddenly narrowed, and with few or no spinules ; two long preapical spines. Hairs of mouth-brush simple. Frontal hairs rarely if ever single, and never placed one in front of the other. Anal segment with a complete chitinous ring (in the fourth stage only). Siphon with numerous ventral tufts, or else greatly elongate.

The genus is essentially tropical and sub-tropical, only a very few species extending into the temperate regions. Only *C. apicalis* and the domestic *C. pipiens* and *C. fatigans* are common to Europe and North America.

Three fairly well-marked subgenera occur within the Palaearctic region, as indicated in the following keys.

Adults.

1. First joint of hind tarsi distinctly shorter than the tibiae ; small obscurely coloured species (*Barraudius*) 2
   First joint of hind tarsi scarcely, if at all, shorter than the tibiae .. 3

2. Abdominal tergites with continuous lateral pale stripes .. *modestus*, Fic.
Abdominal tergites, with basal lateral pale patches.. .. *pusillus*, Mcq.

3. A row of small flat white scales round the margin of the eyes (*Culicomyia*) *impudicus*, Fic.
Scales on the top of the head all narrow (*Culex*) 4

4. Prothoracic lobes and pro-epimera with numerous broad flat scales ; pale bands of abdominal tergites apical (occasionally reduced to lateral spots) 5
Prothoracic lobes and pro-epimera with few or no flat scales 6

5. Hind tibia with a distinct white spot on the outer side at the tip, *hortensis*, Fic.
No such spot .. .. *apicalis*, Adams.

6. Dorsum of abdomen uniformly dark brown ; species without ornamentation *hayashi*, Yam.
Abdominal tergites at least with basal lateral patches of pale scales .. 7

7. Proboscis and tarsi pale-ringed.. 8
Proboscis and tarsi without pale rings 14

8. Anterior two-thirds, or at least the middle third, of the mesonotum with whitish scales, which contrast sharply with the dark scales of the posterior third 9
Thorax not so marked 11

9. Femora and tibiae with numerous small but conspicuous pale dots ; abdominal tergites with basal pale bands or spots only *quasigelidus*, Theo.
Femora and tibiae with the scales mottled, but without conspicuous pale dots ; abdominal tergites with apical pale bands 10

10. Wings with numerous pale scales .. .. .. *bitaeniorhynchus*, Giles.
Wing-scales all dark .. .. *sinensis*, Theo.

11. Wings with conspicuous pale markings 12
Wings unmarked 13

12. Tip of vein Cu_2 (lower branch of fifth) dark-scaled .. .. *mimeticus*, Noé.
Tip of vein Cu_2 pale-scaled .. .. *orientalis*, sp. n.

13. Mesonotal scales all dark reddish-brown, except perhaps round the margin ; middle tibiae without any trace of a pale stripe .. *tritaeniorhynchus*, Giles.
Mesonotal scales mixed light and dark brown ; middle tibiae with a pale anterior longitudinal stripe more or less indicated .. *vishnui*, Theo.

14. Femora and tibiae with distinct pale longitudinal stripes anteriorly (most marked on front and middle legs).. 15
Femora and tibia not striped 16

15. Mesonotal scales dark brown, more or less mixed with lighter ; pale abdominal bands generally triangularly produced in the middle *tipuliformis*, Theo.
Mesonotal scales reddish-brown ; pale abdominal bands gently rounded *virgatipes*, Edw.

16. Abdominal tergites with complete basal pale bands 17
Abdominal tergites with basal pale lateral spots only 20

17. Abdominal bands white 18
Abdominal bands pale ochreous 19

18. Pale abdominal bands very broad ; hind tibiae dark except at tip *laticinctus*, Edw.
Pale abdominal bands narrow ; hind tibiae with a more or less distinct pale lateral stripe .. .. *perexiguus*, Theo

19. Mesonotal scales ochreous-tinged .. .. *fatigans*, Wied.
Mesonotal scales generally reddish-brown .. .. *pipiens*, L.

20. Upper fork-cell in female with a very short stalk; last two joints of male palpi with a white line beneath .. .. .. *pipiens*, L., var.
Upper fork-cell in female with a longer stalk; last two joints of male palpi dark beneath .. .. *laurenti*, Newst.

Male Hypopygia.

1. Side-piece with scales, the lobe scarcely if at all beyond the middle, without flattened plate (*Barraudius*) 2
Side-piece without scales, the lobe well beyond the middle 3

2. Clasper long and slender .. .. *modestus*, Fic.
Clasper shorter and stouter .. .. *pusillus*, Macq.

3. Clasper with a conspicuous spiny crest (?); side-piece with a large and conspicuous tuft of hairs projecting outwards (*Culiciomyia*), *impudicus*, Fic.
Clasper without conspicuous subapical spiny crest; side-piece without conspicuous hair-tuft (*Culex*) 4

4. Lobe of side-piece without an apically situated flattened plate 5
This plate present, or represented by several 6

5. Side-piece with an apical finger-like process; appendages of lobe short *hortensis*, Fic.
Side-piece without finger-like process; appendages of lobe long, *apicalis*, Adams.

6. Lobe of side-piece with several flattened plates .. .. *hayashi*, Yam.
Lobe of side-piece with only one flattened plate 7

7. Plate on lobe of side-piece narrow and pointed 8
The plate broad, rounded, and leaf-like 10

8. Tenth sternites without basal arm .. .. .. *quasigelidus*, Theo.
Tenth sternites with well-developed basal arm 9

9. Mesosome formed of two pairs of upwardly-directed, sickle-shaped structures; basal arm of tenth sternites short .. *bitaeniorhynchus*, Giles.
Mesosome formed of one pair of pointed, almost straight structures; basal arm of tenth sternites long .. .. *sinensis*, Theo.

10. Side-piece with dense hairs round the tip and near the lobe 11
Tip and region near lobe of side-piece not densely hairy 12

11. Clasper greatly widened in the middle, ending in a long, sharp point *orientalis*, sp. n.
Clasper not much widened in the middle .. .. .. *laticinctus*, Edw.

12. Basal arm of tenth sternites well developed 13
Basal arm of tenth sternites very short or absent 19

13. Clasper sickle-shaped, gradually tapering to the tip 14
Clasper somewhat broadened beyond the middle 18

14. Mesosome elaborately divided, the two main divisions each further split up 15
Mesosome much more simple 17

15. Lower division of mesosome with only two or three teeth, which are turned outwards .. .. *mimeticus*, Noé.
Lower division of mesosome with 4–6 teeth, which are spread out finger-like or curved tailwards 16

16. Innermost tooth on mesosome considerably longer than the rest *tritaeniorhynchus*, Giles.
All the teeth approximately equal in size .. .. .. *vishnui*, Theo.

17. Mesosome with two divisions, one of which carries two or three short teeth *tipuliformis*, Theo.
Mesosome (as seen from above) with three simple divisions .. *virgatipes*, Edw.

18. Second division of mesosome simple .. .. *perexiguus*, Theo.
Second division of mesosome divided into several teeth .. *laurenti*, Newst.

19. Second division of mesosome very broad and plate-like .. *fatigans*, Wied.
Second division of mesosome narrow and hook-like .. .. *pipiens*, L.

Larvae.

1. Siphon rather less than three times as long as broad 2
Siphon at least four times as long as broad, generally much more .. 3

2. Siphon pale, all the tufts arranged in a slightly zigzag mid-ventral line; tip of antennae black and much narrowed .. *pusillus*, Mcq.
Siphon blackish; ventral tufts in three or four pairs, the members of which are widely separated; two lateral tufts also present; antennae all pale, tip scarcely narrowed .. [*nebulosus*, Theo.], *impudicus*, Fic.

3. Comb of eighth segment with 4–8 large sharp teeth 4
Comb of eighth segment with numerous small scales in a triangular patch.. 5

4. Siphon with a dark ring at one-third of its length; head very dark; pecten-teeth 6–9 .. .. *quasigelidus*, Theo.
Siphon and head pale; pecten teeth only 2–3 .. *bitaeniorhynchus*, Giles.

5. Siphonal tufts 8–10, in a zigzag ventral row, the first two or three tufts between the pectens .. .. *laticinctus*, Edw.
Siphonal tufts more or less paired, none between the pectens 6

6. Siphon 6–7 times as long as its breadth at the base; or, if a little shorter (*C. tipuliformis*), the pecten teeth have short basal denticles only .. 7
Siphon 4–5 times as long as its breadth at the base; pecten teeth with rather long denticles extending more than half their length 12

7. Pecten spines strong, curved, rather wide apart, with small basal denticles *tipuliformis*, Theo.
Pecten spines smaller, straight and closer together, generally with more numerous denticles 8

8. Siphon distinctly enlarged at the tip, tufts few and small .. *apicalis*, Adams.
Siphon not enlarged at the tip 9

9. Siphonal tufts rather numerous, some much longer than the diameter of the siphon 10
Siphonal tufts fewer, none longer than the diameter of the siphon.. .. 11

10. Antennae pale except on the portion beyond the subapical bristles, which is nearly as long as the part between these bristles and the tuft *mimeticus*, Noé.
Antennae entirely, or at least more than half, dark, subapical bristles quite near tip .. .. *hortensis*, Fic.

11. Antennal tuft at two-thirds; siphonal tufts all subventral (paired) *tritaeniorhynchus*, Giles.
Antennal tuft beyond two-thirds; two pairs of siphonal tufts lateral *perexiguus*, Theo.

12. Siphon about 5×1, pecten teeth averaging 12–15 .. .. *pipiens*, L.
Siphon scarcely 4×1, pecten teeth averaging 9 .. .. *fatigans*, Wied.

Subgenus **Barraudius**, nov.

First joint of hind tarsus distinctly shorter than the tibia. No flat scales on top of head adjoining eyes. Side-pieces of male hypopygium with numerous small scales on the outer side ; lobe situated scarcely beyond the middle, without flattened plate, and with only two or three stout spines. Clasper without subapical spiny crest. Larval mouth-parts normal, not modified for predacity. Siphonal hair tufts arranged mid-ventrally in a single very slightly zigzag line which runs the whole length. Anal segment short, as in typical *Culex*. Type species : *Culex pusillus* (Macq.), Storey.

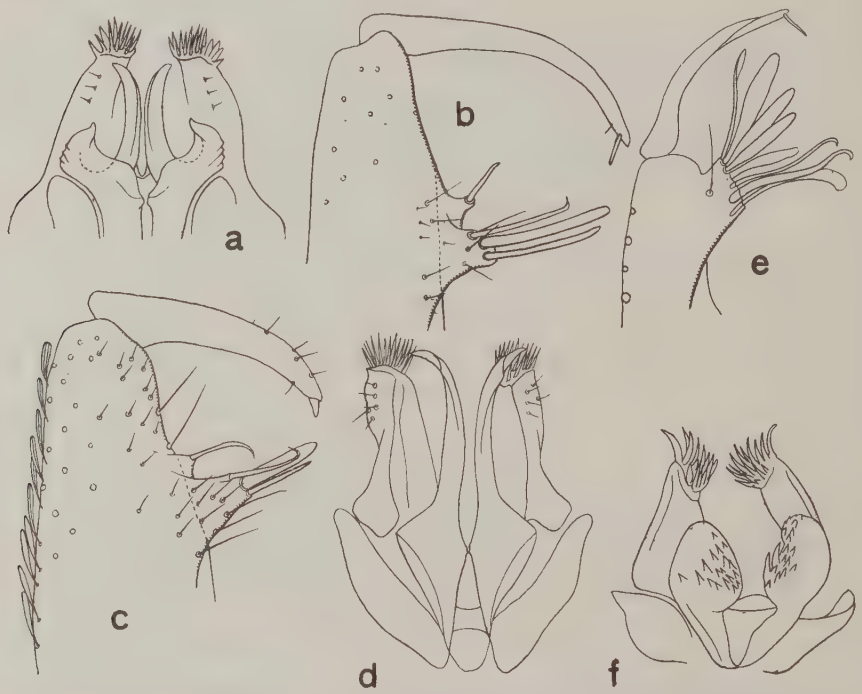

Fig. 12. Hypopygia of Palaearctic species of *Culex*: a, d, f, basal parts, dorsal view ; b, c, e, tips of side-pieces, lateral view, all ×200. a, b, *C. modestus*, Fic. ; c, d, *C. pusillus* (Macq.), Storey ; e, f, *C. hayashi*, Yamada.

The erection of this subgenus is necessary for the reception of two small obscure species from the eastern Mediterranean region. By several of the characters enumerated above they appear to be more distinct from typical *Culex* than any other groups occurring in the Old World.

1. **Culex** (**Barraudius**) **modestus** (Fic.) (fig. 12 a, b).

Culex modestus, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 293 (1890), and xxxi, p. 211 (1899).

Apart from the tarsal character mentioned in the key, the female of this species is not easy to distinguish from the unbanded variety of *C. pipiens*. There is, however, no connection between the two species, which are as widely separated in the structure of the male hypopygium as any two species of the genus. The average size is smaller

than the smallest *C. pipiens*, the integument of the thorax is generally paler and the scales browner. The long, bare male palpi will at once distinguish that sex from *C. pipiens* as well as from all other Palaearctic species except *C. pusillus* and *C. hortensis*. The pale markings of the abdomen have an ochreous tint; the colours of the tergites are either separated in a straight line, or the pale lateral stripes are slightly enlarged apically.

Distribution.—Italy (*Ficalbi*); Hungary (*Kertész;* also Neusiedler See, *Mik*); Macedonia (*Waterston*); Asia Minor (Salyr, Konia and Bashara, *Naday*); Palestine (marsh at Tel Abu Zeitun, *Austen*); perhaps the species recorded from Rumania by Leon as *C. fusculus*.

Fig. 13. *Culex pusillus* (Macq.) Storey, head of larva.

2. **Culex (Barraudius) pusillus** (Macq.) Storey (figs. 12 c, d, 13, 14).

Culex pusillus, Macquart, Dipt. Exot. Supp. iv, p. 9 (1850).
Culex pusillus, Storey, Bull. Soc. Ent. Egypte 1918, (1919).

I did not at first distinguish this species from *C. modestus*, and it was recorded by Barraud under this name. It closely resembles *C. modestus*, but differs quite markedly in the male hypopygium. The claspers are shorter and stouter, there are differences in the lobe of the side-piece, and the anal and genital parts are much more elongate and rather differently constructed. The pale markings of the abdomen are pure white, and thus differ in colour as well as in form and position from those of *C. modestus*.

I have examined the original specimens of Macquart's *C. pusillus*, one of which is in the Vienna Museum and the rest in the Bigot collection in Mr. Collin's possession.

All are in such bad condition that they are totally unrecognisable, but from their size there is no reason to suppose that Storey's identification is incorrect.

The larva was found by Barraud in small numbers near Basra. The accompanying figures have been prepared from a comparison of two mounted skins presented by him to the British Museum. The extremely short siphon, with all the hair-tufts placed in a slightly zigzag row in the mid-ventral line, is very remarkable, and very suggestive of the siphon of *Lutzia*, to which genus *C. pusillus* and *C. modestus* also

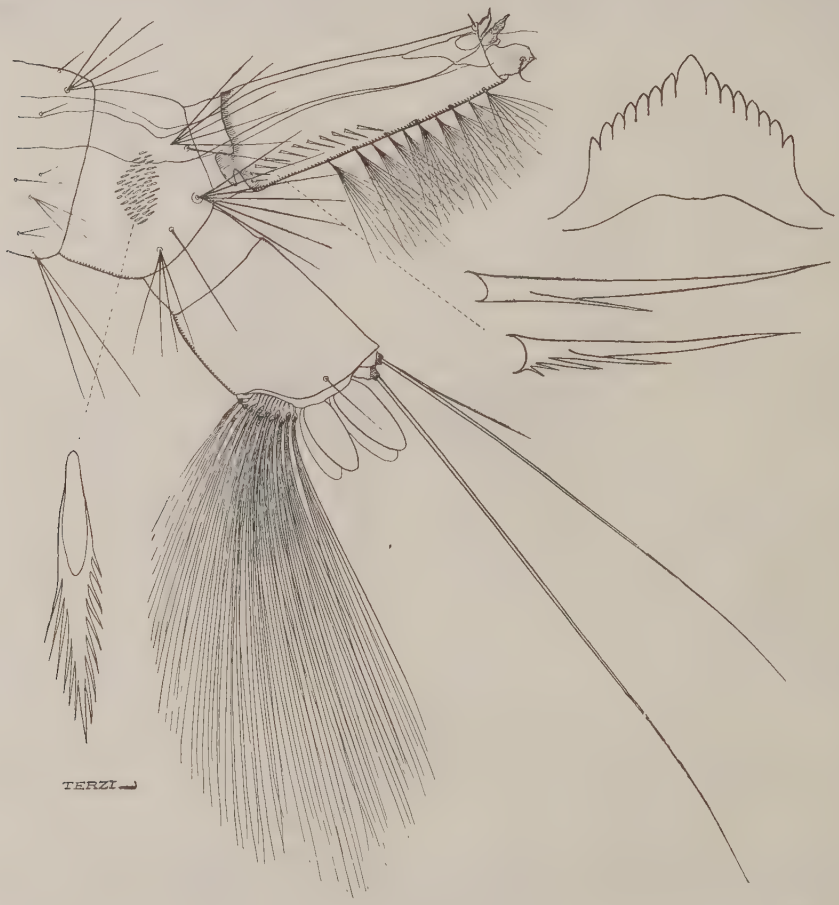

Fig. 14. *Culex pusillus* (Macq.) Storey, end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

show a marked resemblance in the structure of the male hypopygium. There is no sign, however, of any modification of the larval mouth-parts for predaceous habits, and the anal segment is differently shaped.

Distribution.—Egypt (*Storey*). Mesopotamia (*Barraud*).

Subgenus **Culiciomyia,** Theo.

Head in both sexes with a narrow rim of small flat scales along the upper orbital margin. Male palpi with a row of long scales projecting inwards from the apical

half or more of the long joint ; the scales are of peculiar shape, sharply pointed at the tip and more or less widened about the middle. Lobe of side-piece of male hypopygium with two flat plates. Clasper with a conspicuous spiny crest at some distance before the tip, which is rather suddenly narrowed. Tips of tenth tergites with the inner spines slender and sharp-pointed, the outer ones much stouter and blunter. Otherwise as in *Culex*, s. str.

None of the distinctions mentioned above are fundamental, and it may be doubted if the subgenus is worth maintaining. The rather well-marked larval characters of *C. nebulosus* are not shared by the Oriental members of the subgenus.

One species apparently occurs in the Mediterranean region ; another (*C. pallidothorax*, Theo.) is common in south China, and should be looked for in Japan. There are other Oriental and Ethiopian species, but none in Australia or America. In the New World the type is represented by *Choeroporpa*, Dyar.

3. **Culex (Culiciomyia) impudicus,** Ficalbi.

Culex impudicus, Ficalbi, Bull. Soc. Ent. Ital. xxii, p. 81 (1890), and xxxi, p. 214 (1899).

(?) *Culiciomyia nebulosa* (Theobald) Edwards, Bull. Ent. Res. ii, p. 254 (1911).

I do not know *Culex impudicus* except from Ficalbi's works, but his figures of the male hypopygium are so much like the structure to be found in some specimens of *C. nebulosus*, Theo., from the Gold Coast* that I feel certain *C. impudicus* must be a *Culiciomyia* closely related to the African species, and it even seems possible that the apparent differences may be due to inaccuracies in Ficalbi's figures. This conclusion is rendered more probable by the fact that I have examined two females of a *Culiciomyia* indistinguishable from *C. nebulosus* in the Paris Museum collection from Beirut (*Dr. Landrieu*). The species should therefore be determinable easily by the characters mentioned under the subgenus. It is an almost uniformly dark species, with small pale spots at the apical corners of the abdominal tergites.

According to Ficalbi the larvae of *C. impudicus* were found in water-holes with much vegetation used for irrigating gardens in Sardinia, and in large marshes in Sicily. In West Africa *C. nebulosus* breeds in any small collection of water, especially about houses ; it is sometimes found in tree-holes and bamboos.

Subgenus **Culex,** s. str.
(including *Neoculex*, Dyar).

Head without any small flat scales in the middle in front. Male palpi without a row of outstanding scales on the long joint. Usually 5–7 pro-epimeral bristles, some smaller than others. First joint of hind tarsus as long as the tibia, or very slightly longer or shorter. Side-pieces of male hypopygium without scales, the lobe well beyond the middle, normally with a flat plate as well as four or five modified bristles. Clasper without definite spiny crest. Larva with the siphonal tufts more or less paired, not all in the mid-ventral line, no tufts on basal fourth or more of siphon.

The members of this subgenus exhibit a fair amount of diversity, but it does not seem to me that any groups are sufficiently circumscribed to be treated as subgenera. Dyar's *Neoculex* (to which belong *C. hortensis* and *C. apicalis*) cannot be defined on any larval character, while even the hypopygial characters on which it is based are closely approached by *C. sinensis*, from which species by slight gradations (through *C. quasigelidus* and other allied forms) the typical *Culex* structure is soon reached.

* There are, I find, two definite varieties or species of *Culiciomyia* in Africa, distinguishable by hypopygial differences. I have not yet estimated the precise relationship of these two nor their distribution. If either is synonymous with *C. impudicus* it will of course have to take Ficalbi's name, but it is perhaps more likely that the Mediterranean form is distinct.

4. **Culex hortensis,** Ficalbi.

Culex hortensis, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 27 (1889), and xxxi, p. 217 (1899).
Maillotia pilifera, Theobald, Mon. Cul. iv, p. 274 (1907).
Culex geniculatus, Theobald (*nec* Olivier), Mon. Cul. iii, p. 216 (1903).

Easily distinguished from the other Palaearctic species with dark tarsi by the apically situated bands on the abdominal tergites and from its ally *C. apicalis* by the white spot at the tip of the hind tibia, and the bare male palpi. The abdominal bands are variable in width, being reduced occasionally to lateral spots only.

The larvae are said to prefer weedy ponds, particularly those covered with duckweed.

Distribution.—Throughout the Mediterranean region and central Europe, extending as far north as Paris and Berlin. Some new records are: Corsica (*Mann*); Asia Minor (Ereckli, Sabanja, *v. Bodemeyer*); Germany (Berlin, Schildhorn, *Oldenberg,* 1 ♀); Transcaspia (Firudza, *C. Ahnger*); Syria (Beirut, *Landrieu*).

5. **Culex apicalis,** Adams.

Culex apicalis, Adams, Kansas Univ. Sci. Bull. ii, p. 26 (? June 1903).
Culex sergenti, Theobald, Mon. Cul. iii, p. 218 (July 1903).
Culex pyrenaicus, Brolemann, Ann. Soc. Ent. France, lxxxvii, p. 427 (1919).
Culex territans, Howard, Dyar & Knab, Monogr. iv, p. 293 (1912) (*nec* Walker).

In spite of the great differences in the male hypopygium, there can be no doubt that this is closely related to *C. hortensis.* The most obvious distinctions of *C. apicalis* are the hairy terminal joints of the male palpi and the dark tip of the hind tibia. The wing-scales seem to be a little narrower, and the pale abdominal bands are also perhaps on the average narrower. It may not always be possible to distinguish the females with certainty; Eckstein states that they differ from those of *C. hortensis* in having the bases of the abdominal sternites dark-scaled, but I cannot confirm this.

The larva differs from that of *C. hortensis* in the bicoloured antennae, in the shape of the siphon, and in the smaller and less numerous siphonal tufts. The two species are said by Séguy to breed under similar conditions, though according to Eckstein *C. apicalis* is found in clear water.

Distribution.—Occurs over a wide area in Europe and North America, apparently also in North Africa, though I have seen only females from there (including Theobald's type of *C. sergenti*) and am not absolutely certain of their identity. Some new records are: Tunis (Tamerza, *Langeron,* ♀); Italy (Gorizia, *Mik,* ♂ ♀); Carniola (Wippach, *Handlirsch*); Transcaspia (Amudaria, *C. Ahnger*).

6. **Culex hayashi,** Yamada (fig. 12 e, f).

Culex hayashi, Yamada, Dobuts. Z. Tokio, xxix, pp. 61–72 (1917).

This differs from all other species known from the Palaearctic region in having the male palpi straight and considerably shorter than the proboscis (about three-quarters as long), but there are several other Oriental species with which it might be confused, such as *C. brevipalpis* (Giles) and *C. jenseni* (Meij.). The male hypopygium is also very distinct, on account of the structure of the mesosome and the numerous plates on the lobe of the side-piece; in the former point *C. hayashi* much resembles the subgenus *Lophoceratomyia,* but it does not show any modification of the male antennae, nor any flat scales on the top of the head; it should perhaps be placed in Dyar's subgenus *Neoculex,* if that is adopted. The species is unicolorous brown, only the lower side of the abdomen somewhat lighter. The scaling is that of a normal *Culex,* but there seem to be some flat scales on the prothoracic lobes.

Dr. Lamborn found the larvae in muddy pools in company with those of *Anopheles punctibasis*.

Distribution.—Japan (Tokio, *Yamada*, a series presented by the collector to the British Museum in 1915; Nagasaki, *Lamborn*).

7. **Culex quasigelidus,** Theobald.

Culex quasigelidus, Theobald, Mon. Cul. iii, p. 181 (1903); Edwards, Bull. Ent. Res. ii, p. 258 (1911).

This is one of the most distinct members of a rather large group of tropical species, which Theobald included in his genus *Leucomyia*. The leg markings are distinctive, but are not at all unlike those of the Old World species of *Lutzia*, especially *L. tigripes*, of which *C. quasigelidus* has been taken to be a variety, though in reality it is very different. The larvae, like many others with long siphons, live in weedy pools; they are very similar in structure to those of the other members of this group.

Distribution.—Widely spread in the Ethiopian region, occurring in Madagascar, and spreading northward by the Nile valley as far as Alexandria.

8. **Culex bitaeniorhynchus,** Giles.

Culex bitaeniorhynchus, Giles, J. Bombay Nat. Hist. Soc. xiii, p. 607 (1901); Edwards, Bull. Ent. Res. iv, p. 231 (1913).

The wing-scales of this species are unusually broad for a *Culex*, and on this account Theobald placed it in the genus *Taeniorhynchus*, with which it has really no connection. Usually the pale scales on the wings are almost as numerous as the dark ones, at least in the female, but a variety occurs in which they are comparatively few and scattered. The femora and tibiae are also very much mottled. The pale bands of the abdomen are very variable in width; they may be very narrow, or the abdomen may be almost all pale. The species is semi-domestic, the larva often living in polluted water.

Distribution.—Throughout the Oriental region; occurring also in Japan and North Australia. A variety, differing slightly in the male hypopygium, is widely spread in Africa.

9. **Culex sinensis,** Theobald.

Culex gelidus var. *sinensis*, Theobald, Mon. Cul. iii, p. 180 (1903).
Leucomyia sinensis, Theobald, Mon. Cul. v, p. 313 (1910).
Culex sinensis, Edwards, Bull. Ent. Res. iv, p. 231 (1913).

This is at first sight very much like *C. bitaeniorhynchus*, but differs in the much narrower and entirely dark wing-scales, and very considerably in the male hypopygium. Apart from this, the femora and tibiae are less mottled, the pale scales which are present tending to be aggregated into small dots, though these are not nearly so conspicuous as in *C. bitaeniorhynchus*.

Distribution.—Widely spread in the Oriental region, and, like the last species, occurs also in Japan (Tokio, *Yamada*), but is not known from Australia or Africa, where it seems to be represented by allied but distinct species.

10. **Culex mimeticus,** Noé.

Culex mimeticus, Noé, Bull. Soc. Ent. Ital. xxxi, p. 240 (1899).

A very interesting species on account of the spotted wings, the markings comprising three pale ochreous areas on the costa, which extend on to the first vein,

also other pale areas, the most noticeable of which are in the middle of the third vein and towards the base of the sixth. The fifth vein is entirely dark, except for a part of its upper branch. The wing-scales are narrow but rather short. The proboscis has a well-defined pale ring about the middle in both sexes. The male palpi have pale rings at the bases of the last two joints and a very narrow one at the tip of the last joint. The side-pieces of the hypopygium are only moderately hairy; the lobe with the usual five modified bristles (the apical one unusually flattened and outwardly directed) and leaf-like plate; clasper sickle-shaped, gently tapering, with well-marked terminal claw; tenth sternites with the basal arm quite long, though shorter than the sternites; second division of mesosome split into two or three teeth.

The larva has been partly described and figured by Martini, but he has omitted to notice an important point, the position of the pair of subapical antennal bristles only a little more than mid-way between the tuft and the apex of the shaft. It is also noteworthy that the pale colour of the antenna extends some way beyond the tuft, almost to the subapical bristles. The 4 or 5 pairs of larger siphonal tufts are at least twice as long as the diameter of the tube. The larva is remarkably like that of *C. hortensis*, differing in antennal characters and in the rather greater number of siphonal tufts; the latter point is probably not of much importance, as the number and also the position of the tufts is certainly variable in many species of the genus.

The most interesting fact about this species is its occurrence in association with *Anopheles superpictus*, to which it bears a considerable resemblance in wing-markings. Whether we have a genuine case of mimicry, and if so what advantage the species could gain by it, I will not attempt to judge, but it is perhaps an even more remarkable fact that the allied *C. mimulus*, which differs in having a dark third vein, occurs with *Anopheles culicifacies* or *A. minimus*, which differ in the same way from *A. superpictus*.

Distribution.—Mountainous regions in the eastern Mediterranean region. Italy (*Noé*); Macedonia (*Martini, Waterston*); Palestine (*Cropper*); Cyprus (*Miss Bate*).

The species was till recently supposed to have a much more extended distribution, but I have recently shown that the form inhabiting Ceylon and Malaya differs slightly both in wing markings and hypopygial details, and have therefore treated it as a distinct species, *C. mimulus*. There are good larval differences between *C. mimeticus* and *C. mimulus*, the latter having few and short siphonal tufts, and the subapical antennal bristles close to the tip. A second form, which is probably equally distinct, is found in Hong Kong, Formosa, and South India (Ootacamund, recorded by me recently as *C. mimeticus*). This differs from the true *mimeticus* in the much broader pale tip to the longer male palpi, the absence (apparently not quite constantly) of the basal arm of the tenth sternites, and perhaps in other details. I have seen only females from North India, and cannot say whether they belong to this second Oriental form or to the true *mimeticus*. The Japanese form must obviously be treated as another quite distinct species.

11. **Culex orientalis,** sp. n.

Differs from *C. mimeticus* as follows:—Wing-scales somewhat broader and distinctly longer, the wings therefore appearing more densely scaled. Cu_2 (lower branch of fifth vein) with a pale area at its tip, most noticeable in the female; another pale area (more or less developed) before the fork. Male proboscis with numerous pale scales on the apical portion beyond the ring, sometimes the whole apical portion is pale. Hypopygium: side-pieces large and stout, densely hairy, especially round the somewhat produced tip and near the lobe; lobe with eight somewhat flattened appendages, all much alike, with rounded, not hooked tips, and placed almost in a continuous row; besides these there are numerous accompanying long hairs; leaf-like plate and its accompanying bristle present as usual. Clasper

very large, flat, very much broadened a little beyond the middle, ending in a rather long sharp point ; terminal claw very minute ; subapical spiny crest slightly indicated. Tenth sternites with moderate basal arm. Second division of mesosome with three rather large teeth and about five small ones.

The hypopygium is more like that of *C. laticinctus* than that of *C. mimeticus*. It would be of interest to know whether there is any similar resemblance in the larvae.

Distribution.—Japan (Tokio, *Yamada*). A series presented by the collector to the British Museum in 1915 was determined by me then as *C. mimeticus*, but a closer study reveals the striking differences enumerated above. Also Yokohama and Kobe (*Lamborn*) ; the larvae in rice-fields in company with *Anopheles hyrcanus*.

12. **Culex tritaeniorhynchus,** Giles.

Culex tritaeniorhynchus, Giles, J. Bombay Nat. Hist. Soc. xiii, p. 606 (1901) ; Edwards, Bull. Ent. Res. iv, p. 233 (1913), and vii, p. 224 (1917).

This species is sufficiently distinguished by the characters mentioned in the key, but I have given a number of others in the papers quoted above. The average size is very small (3 mm.), but in this respect the species varies a good deal in different parts of its range, Japanese examples being much larger than those from Palestine.

Larvae have been received from Capt. Barraud from Mesopotamia ; they are remarkably similar to those of *C. perexiguus*, described below ; I can discover very few differences beyond those mentioned in the key, which seem most likely to be constant. Other larvae from Ceylon differ slightly from these, but not to such an extent that they need be separated specifically. They are found usually in salt marshes, often in company with other small species with a banded proboscis (*C. vishnui* or *C. sitiens*).

Distribution.—Palestine and Mesopotamia (*Barraud*) ; Palestine (Khirbet Hardrah, *Austen ;* Jerusalem, *Goldberg*) ; Japan (Tokio, *Yamada ;* Chuzenji, *Gallois ;* Nagasaki, *Lamborn*) ; China (Shanghai, *Lamborn*, etc.). Also throughout the Oriental region and on both the east and west coasts of Africa.

13. **Culex vishnui,** Theobald.

Culex vishnui, Theobald, Mon. Cul. i, p. 355 (1901) ; Edwards, Bull. Ent. Res. iv, p. 233 (1913), and vii, p. 225 (1917).

In spite of the very slight difference in the hypopygia (there are perhaps some other slight distinctions besides the one mentioned in the key) I feel sure this species is distinct from *C. tritaeniorhynchus*, its closest ally and frequent associate. *C. vishnui* breeds in rice-fields, salt-marshes, and elsewhere. No isolated larvae have been received at the British Museum, nor has a description of the early stages been published. The hypopygium is very similar to that of *C. mimulus*.

Distribution.—Mesopotamia (*Barraud*) ; Japan (Osaka, *Theobald*). Also throughout the Oriental region, but as yet unknown from Africa.

14. **Culex tipuliformis,** Theo. (figs. 15, 16).

Culex tipuliformis, Theobald, Mon. Cul. ii, p. 325 (1901) ; Edwards, Bull. Ent. Res. ii, p. 262 (1911), and iii, p. 31 (1912).
Culex creticus, Theobald, Mon. Cul. iii, p. 189 (1903).

Apart from the striped femora and tibiae, and the more or less produced abdominal bands, this might easily be mistaken for *C. pipiens*, especially in rubbed specimens. It is, however, generally darker in colour, the upper fork-cell is not so long, and the

cross-veins, though variable in position, tend to be more approximated than in *C. pipiens,* being occasionally almost in one line. As in *C. pipiens,* the last two joints of the male palpi have whitish markings beneath, but in this species the pale scales tend to be arranged more in patches, one of which is at the tip of the last joint.

The larva has been described by Bedford from the Transvaal (U.S. Afr. Dept. Agr., 5th & 6th Repts. Director Vet. Res., 1919, p. 741), his description and figure agreeing in the main with specimens I have examined, though he shows shorter and more numerous tufts on the siphon. The accompanying figures are based on Capt. Barraud's material. The siphon is distinctly longer than that of *C. pipiens,* index about 5·5–6.* The pecten teeth are 6–9 in number, but rather widely spaced, and reaching beyond a third of the length of the siphon. The first few teeth are quite small, but the last four or five are long, curved, and almost simple, only one or two small basal denticles being present. The antennae are dark at the tip and at the extreme base, pale in the middle, the tuft being placed at about three-fifths. The head is more or less extensively dark basally. The siphon

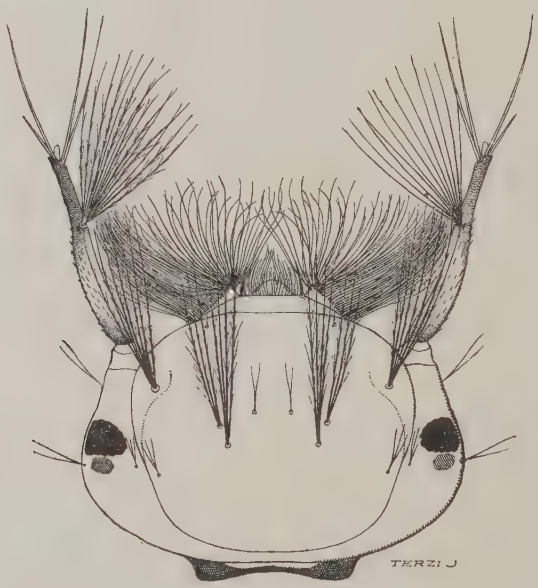

Fig. 15. *Culex tipuliformis,* Theo., head of larva.

is generally all pale, but among the specimens sent by Capt. Barraud from Mesopotamia there are several which have the basal half of the siphon dark or even black ; these specimens also appear to have the siphon a little shorter than usual, but the adults issuing from them do not differ appreciably from normal *C. tipuliformis.*

Distribution.—Atlantic islands ; Mediterranean region generally ; extending through East Africa to the Cape and by way of Persia into north India and Assam ;

* By the siphonal index I mean the ratio of the diameter of the *base* of the siphon to the length, the valves not being reckoned into the length. Séguy apparently takes the ratio of the *average* width to the length.

a rather remarkable distribution, which is exactly parallelled by that of *Theobaldia longiareolata*. I believe the following are new records:—Asia Minor (Konia and Bashara, *Naday*) ; Persia (Enzeli, *Buxton*) ; West Caspian (Lenkoran, *Karsch*) ; Libyan Desert (Bulag, *W. J. H. King*).

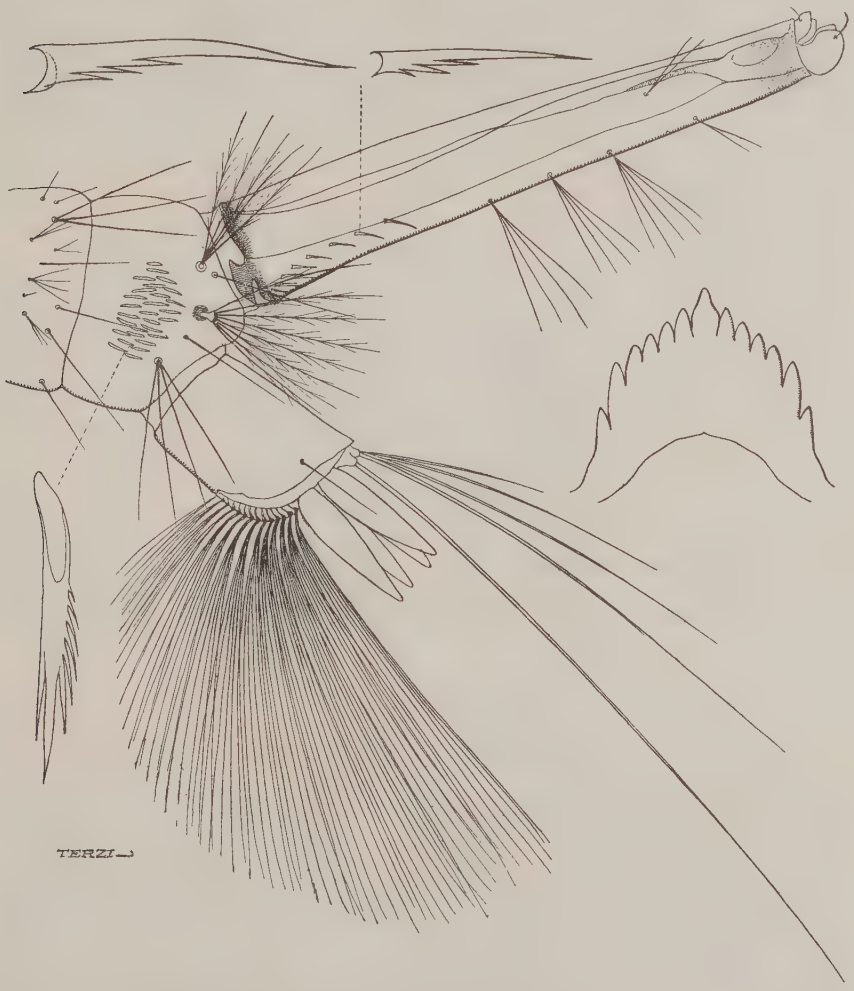

Fig. 16. *Culex tipuliformis*, Theo., end of abdomen of larva ; comb and pecten teeth and mentum more highly magnified.

15. **Culex virgatipes,** Edw.

Culex virgatipes, Edwards, Bull. Ent. Res. v, p. 126 (1914).

Differs from *C. tipuliformis* in the male hypopygium, which is extremely similar to that of the African *C. trifilatus*, Edw., in the uniformly reddish-brown mesonotal scales and in the abdominal markings. The cross-veins are on the average more

widely separated than in *C. tipuliformis*, and the femoral and tibial stripes, though quite distinct, are rather narrower in this species. The resemblance to *C. pipiens* is much more close than in the case of *C. tipuliformis*, the leg-markings affording the main external distinction. The larva is undescribed; it was found by Dr. Lamborn in company with that of *C. fatigans*.

Distribution.—So far as our present knowledge goes, this species is confined to the eastern part of the Palaearctic and Oriental regions, into which *C. tipuliformis* apparently does not extend. Hong Kong (*Macfarlane*); Sikkim (*Wyville-Thompson*); Vladivostok and River Amur (*Wuorentaus*: Helsingfors Museum); Shanghai *Lamborn*).

16. **Culex laticinctus,** Edw.

Culex laticinctus, Edwards, J. Proc. Asiatic Soc. Bengal, ix, p. 49 (1913).

This species differs markedly from *C. pipiens*, the one to which it approaches most nearly in size and appearance, in the pure white abdominal bands, which are as broad as or broader than the dark bands which alternate with them. The male palpi are no longer than the proboscis, and are less hairy than those of *C. pipiens*. The prothoracic lobes often show a number of flat scales on the lower part. The hypopygium is not unlike that of *C. orientalis*, especially in the form and hairiness of the side-piece, but the appendages of the lobe and the structure of the mesosome are different.

The rather remarkable larva has been described and figured by Storey as "Culex sp. no. 2258."

Distribution.—Throughout the Mediterranean region; Canary Islands (Orotava, *Graham-Smith*); southern Spain (Aguilas, *G. Boag*); southern France, and as far north as Paris (*Séguy*); Tunis (Tamerza, *Langeron*; Djerba, *in coll. Bezzi*); Anatolia (Budrum, Mus. Civ. Genova); Cilicia, Syria and Palestine (*Barraud*; Mt. Carmel, *Austen*; Jerusalem, *Goldberg*); Egypt (*Storey*); Arabia (Muscat, *Gill*).

17. **Culex perexiguus,** Theobald (figs. 17, 18).

Culex perexiguus, Theobald, Mon. Cul. iii, p. 199 (1903).

The very small size of this species, together with the narrow white (not ochreous-white) abdominal bands, and the pale stripe on the outer side of the hind tibia (not always very clearly marked, and in the male sometimes indistinguishable), will serve to separate it from other members of the group with dark tarsi and basally banded abdominal tergites. Apart from this, and the aedoeagal structure, *C. perexiguus* may be known by the colour of the mesonotal scales, dark brown mixed with brassy ochreous.

I cannot detect any difference whatever between the adults of *C. perexiguus* and the West African form of *C. univittatus*, either in external characters or male hypopygial structure. The larvae, however, seem to be utterly different. Some confusion has existed regarding the larvae of *C. univittatus*, but Dr. Ingram assures me that the larva described and figured by him and Dr. Macfie (Bull. Ent. Res. x, p. 68) was identified by the isolation method, and he is sure that no error occurred. The figure indicates a larva similar in many respects to that of *C. quasigelidus*, but with several remarkable features, such as the possession of only a single pair of minute siphonal tufts and an incomplete ring on the anal segment.

Larvae of *C. perexiguus* sent from Palestine by Capt. Barraud differ in practically every detail from the larva described by Ingram and Macfie, almost the only point

of resemblance being in the length of the siphon. The accompanying figures have been prepared from isolated skins sent by Capt. Barraud, the adults issuing from which I have examined. The following is Capt. Barraud's description :—

"Antenna light in colour except towards base and tip. Shaft clothed with spicules. Antennal tuft of about 24 subplumose hairs arising at about three-quarters from the base. Mid frontal hair tufts of subplumose hairs ; ante-antennal tuft of 8 hairs ; outer median tuft of 2, inner median of 3. Small lateral tuft above eye of about 4 very small hairs. Mental plate with 7 teeth on either side of the central one, the outermost tooth some distance below the others.

"Siphon about seven times as long as the width at base. Pecten of from 11–14 teeth; teeth slightly curved, with three secondary spines on one side ; last few teeth *slightly*

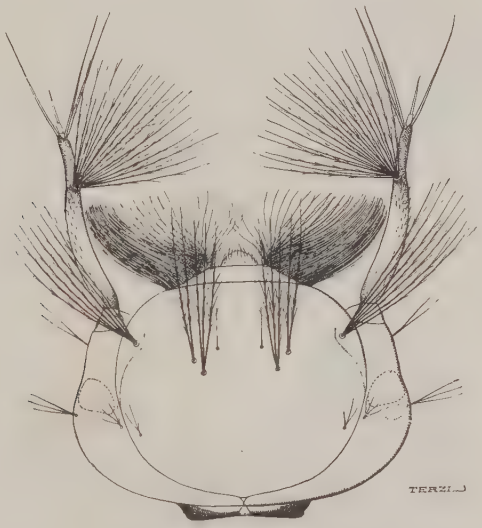

Fig. 17. *Culex perexiguus*, Theo., head of larva.

more detached than the remainder. Hair tufts on siphon represented by about four pairs of very short and fine hairs (towards tip usually single). Tufts on eighth segment of from 4 to 6 subplumose hairs. Comb of small teeth in triangular patch. Anal gills about the length of the anal segment, the dorsal pair rather longer than the ventral. Two or three hairs in the tuft on the dorsal edge of the anal segment. Brush well developed, about 12 tufts each with about 6 hairs."

Since it is impossible to consider two such different larvae as belonging to the same species, there is no alternative but to revive Theobald's name *perexiguus* for the Mediterranean form.

Distribution.—Palestine (*Cropper, Barraud*). Since it is impossible to separate the adults, the further distribution of *C. perexiguus* as distinguished from *C. univittatus* cannot be given, but it seems reasonable to assume that the form is the same throughout the Mediterranean region. From an examination of adults and from Storey's remarks on the larva it is obvious that this is the species he has recorded

from Egypt as *C. decens;* the larva of the African *C. decens* is indeed very similar, though the hypopygium differs. It is perhaps also the species recorded from Algeria by the Sergents as *C. fatigans*, since they state that the siphon is longer than that of *C. pipiens*. Adults, probably of *C. perexiguus*, have been received from southern Spain (*Fowler*), Muscat (*Gill*) and Amritsar, Punjab (*Barraud*).

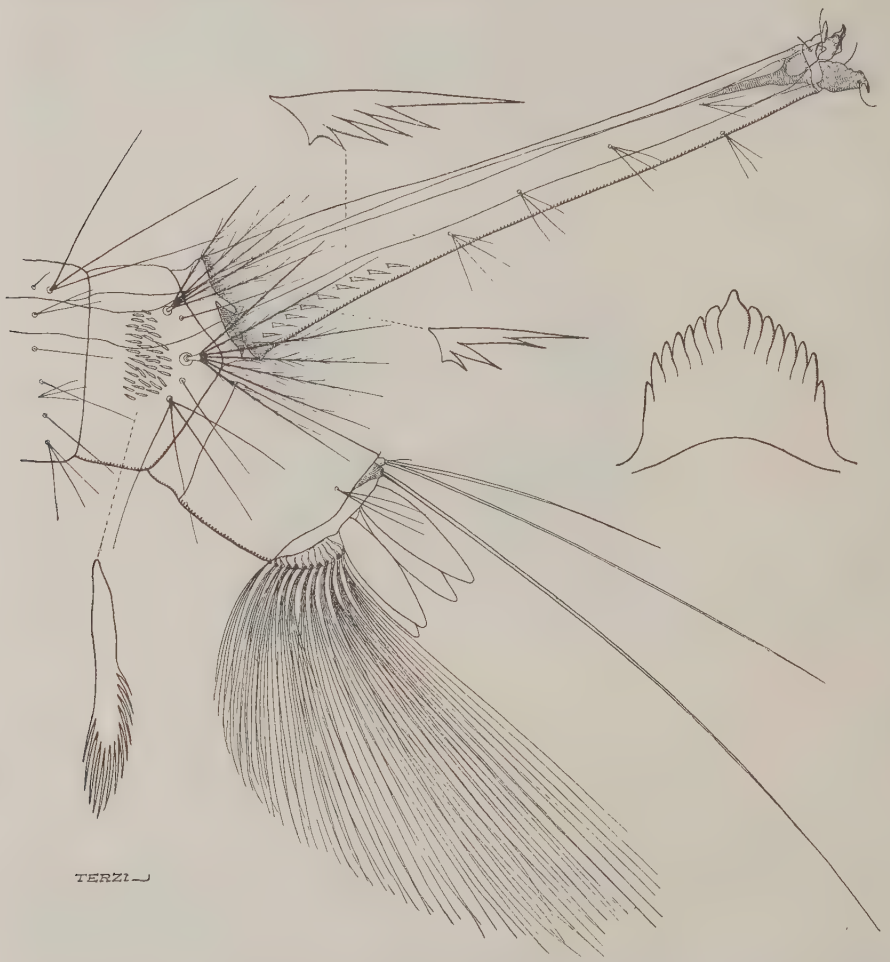

Fig. 18. *Culex perexiguus*, Theo., end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

18. **Culex laurenti,** Newst.

Culex laurenti, Newstead, Ann. Trop. Med. i, p. 24 (1907); Edwards, Bull. Ent. Res. v, p. 70 (1914).

The female of this species is almost impossible to distinguish from the unbanded variety of *C. pipiens*. The male differs from both *C. pipiens* and *C. perexiguus* in having no pale line beneath the last two joints of the palpi. I have figured the

hypopygium in the paper quoted. According to Storey the larvae are indistinguishable from those of *C. perexiguus*.

Distribution.—An Ethiopian species, known from Madagascar, Zanzibar, and the Congo, which has also been recorded from Egypt by Storey as *C. invidiosus*. Also found in Egypt by Austen (Kantara, Suez Canal). Perhaps occurs in Palestine (Acre and Jerisheh, *Austen;* females only).

19. **Culex fatigans,** Wied.

Culex fatigans, Wiedemann, Aussereurop. zweifl. Ins. p. 10 (1828).
Culex quinquefasciatus (? Say), Howard, Dyar and Knab, Monogr. iii, p. 345 (1915).

This species may be distinguished from *C. pipiens* by the combination of some or all of the following characters:—Mesonotal scales somewhat coarser, with a dull brownish-ochreous instead of a dark brown or reddish-brown tinge (but Japanese and American specimens are often as red-tinged as *C. pipiens*). Upper fork-cell shorter in both sexes, that of the female being less instead of more than three times as long as its stem. Male palpi somewhat shorter and less hairy. Pale abdominal bands of the female rather more rounded. The only absolutely reliable distinction between the adults is, however, in the structure of the aedoeagus (see figures in Bull. Ent. Res. iv, pp. 54, 55). The larvae are rather more easily separated than the adults by the characters mentioned in the key.

Distribution.—This species, almost universal in the tropics, has a very limited area of occurrence within the Palaearctic region. I have only seen it from Lower Mesopotamia (*Barraud*), Seistan, eastern Persia (*Annandale*), and Japan (Kobe and Nagasaki, *Lamborn*). It has been recorded by various observers from southern Europe and North Africa, but I consider it highly probable that all such records refer to other species.

20. **Culex pipiens,** L.

Culex pipiens, Linnaeus, Syst. Nat. Ed. x, p. 602 (1758).
(?) *Culex fasciatus,* Müller, Fauna Insectorum Fridrichsdalina, p. 87 (1764).
(?) *Culex molestus,* Forskål, Descriptiones Animalium, p. 85 (1775).
(?) *Culex luteus,* Meigen, Klass. i, p. 6 (1804).
(?) *Culex domesticus,* Germar, Reise nach Dalmatien, p. 290 (1817).
Culex rufus, Meigen, Syst. Beschr. i, p. 7 (1818).
(?) *Culex bicolor,* Meigen, Syst. Beschr. i, p. 9 (1818).
(?) *Culex pallipes,* Waltl, Reise Tyrol etc. ii, p. 110 (1835).
Culex pallipes, Macquart, Dipt. Exot. i, i, p. 33 (1838).
(?) *Culex pallipes,* Meigen, Syst. Beschr. vii, p. 1 (1838).
(?) *Culex meridionalis,* Leach, Zool. Journ. ii, p. 292 (1825).
Culex marginalis, Stephens, Zool. Journ. i, p. 455 (1825).
(?) *Culex thoracicus,* Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii, p. 409 (1827).
(?) *Culex calcitrans,* Robineau-Desvoidy, *loc. cit.*
(?) *Culex rufinus,* Bigot, Expl. Scient. Tunisie Dipt. p. 7 (1888).
Culex agilis, Bigot, Ann. Soc. Ent. France (6) ix, Bull. cxii (1889).
Culex phytophagus, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 126 (1890), and xxviii, p. 286 (1896).
Culex haematophagus, Ficalbi, Bull. Soc. Ent. Ital. xxv, p. 143 (1893).
Culex pallens, Coquillett, Proc. U.S. Nat. Mus. xxi, p. 303 (1898).
Culex melanorhinus, Giles, Gnats, p. 342 (1900).
Culex longifurcatus, Becker, Mitt. Zool. Mus. Berlin, ii, p. 68 (1904).

Culex nigritulus, Theobald, Mon. Cul. i, p. 140 (1901) (*nec* Zetterstedt).
Culex varioannulatus, Theobald, Mon. Cul. iii, p. 198 (1903).
Culex azoriensis, Theobald, Mon. Cul. iii, p. 210 (1903).
Culex quasimodestus, Theobald, Ann. Mus. Nat. Hung. iii, p. 88 (1905).
Culex osakensis, Theobald, Mon. Cul. iv, p. 439 (1907).
Culex pipiens var. *doliorum*, Edwards, Entom. xlv, p. 263 (1912).
(??) *Culex nigritulus*, Wesenberg-Lund, Danske Vid. Selsk. Skr. Nat. Math. Afd. (8) vii, p. 131 (1921).

The distinctions in external characters between the adults of *C. pipiens* and *C. fatigans* have been enumerated above. I have found them reliable in sorting out Mesopotamian specimens, where the two species occur together and *C. pipiens* is fairly constant; but in the southern and eastern Mediterranean region *C. pipiens* is subject to so much variation that the hypopygial differences would have to be relied on; the structure of this organ in *C. pipiens* is fairly constant, the slight variation that does occur showing usually little or no approach to *C. fatigans*.

The examination of a number of mounts of hypopygia of Japanese specimens, however, seems to show that the Japanese race of *C. pipiens* differs constantly from the European, having the second division of the mesosome much broader than usual and the third division not quite so stout, thus being to some extent intermediate between *C. pipiens* and *C. fatigans*. Theobald's type male of *Culex osakensis*, which in 1912 I took to be *C. fatigans*, belongs to this form, but Coquillet's name *pallens* is no doubt also applicable, and should be used to designate the variety. It would seem from their figures that Dyar and Knab's *Culex comitatus*, described from California, belongs to this var. *pallens* rather than to typical *C. pipiens*, and it is quite likely to have been introduced into California from Japan. In both *C. pipiens* and *C. fatigans* a minute basal arm to the tenth sternites may be present or absent.

A variety of frequent occurrence in the Mediterranean region has the pale bands of the abdomen reduced to lateral spots, either in the female only, or in both sexes. There are also two other varieties worthy of special mention. In North Africa many specimens occur with the mesonotal scales more or less ochreous, and in some the dark parts of the abdomen also tend to this colour, so that it is tempting to assume that we have here an incipient modification in colour to suit desert conditions. I have examined the hypopygium of one specimen so coloured, and have no doubt as to its identity. Theobald has described this variety as *C. quasimodesta*, but it is doubtful if it is at present more than a sporadic variation. The second variation is in the length of the upper fork-cell of the female. Over the greater part of the range of the species this is fairly constant, but in the Levant and Asia Minor many specimens are found in which the cell is shorter than usual, and little, if any, longer than that of *C. fatigans*. It seems rather significant that this very region is on the borders of the range of *C. fatigans*; the possibility of interbreeding may be indicated, but, against this, it should be noted that such intermediate specimens have not been found in Mesopotamia, where the two species are known to occur together.

I am indebted to Capt. Barraud for calling my attention to the existence of what seems to be a definite larval variety of *C. pipiens* in Palestine and Syria. In this form the average number of pecten-teeth is 12, and there seems to be little variation from this; of 39 specimens critically examined by Capt. Barraud, no fewer than 24 had either 12 or 13 pecten teeth, the number in the remaining specimens varying from 9 to 17. Further distinctions of this Levantine race are the smaller average size, the lighter-coloured antennae, and the shorter average length of the siphon (index about 4·5).

Capt. Barraud found that in Mesopotamian specimens the average number of pecten teeth was greater and the range of variation more. Out of 27 specimens examined the average number of teeth was 15·7; only 10 specimens had either 15

or 16 teeth, the number in the others ranging from 12 to 20. These specimens also had dark antennae, and the average size was larger and the average length of the siphon rather greater (index about 5). I find that specimens from Britain and Macedonia, though rather variable, agree in the main with this Mesopotamian type, which may therefore be taken as the common European form.

I have not been able to detect any constant difference between Palestine adults and those of other countries. Both the banded and unbanded forms occur there, and, as mentioned above, some (but by no means all) of the females have the upper fork-cell shorter than usual. It may be noted that in its several peculiarities the Palestine larva of *C. pipiens* approximates to that of *C. fatigans*.

It is possible, as long ago suggested by Ficalbi, that there are two races of this species, differing little, if at all, externally, but one being more addicted to sucking human blood than the other. In England *C. pipiens* will certainly attack man at times, but can seldom be regarded as troublesome ; I have never myself experienced its bite, nor found a blood-gorged female in a bedroom. In south Europe, however, the reports of various observers lead one to suppose that it is more regularly addicted to feeding on human blood. Further experience may possibly show that the Palestinian type of larva described above is widely distributed in the Mediterranean region and represents the more troublesome race. If this should be proved to be the case the varietal name *molestus*, Forskål, might be applied to this form.

Wesenberg-Lund describes as *C. nigritulus*, Theo., a *Culex* larva which seems to differ in many respects from *C. pipiens* : *e.g.*, in the shape of the mentum and of the pecten-teeth and comb-scales and in the longer siphon. As I have not seen the adults reared from these larvae, I will only remark that the larvae of my *C. pipiens* var. *doliorum* (which I considered identical with Theobald's *C. nigritulus*, and which I do not now consider even varietally distinct from *C. pipiens*) conform fairly well to Wesenberg-Lund's description of *C. pipiens*.

Synonymy.—It is impossible to say what species were actually intended by most of the old descriptions, but I think it probable that the names *C. bicolor*, Mg., *C. pallipes*, Mg., *C. thoracicus*, R.-D., *C. calcitrans*, R.-D., and perhaps also *C. luteus*, Mg., were based on more or less rubbed specimens of this species. From the habits indicated by Forskål and Germar for *C. molestus* and *C. domesticus* it seems probable that this species was intended, *C. fatigans* being excluded owing to its now apparently established absence from Europe and Egypt. The description of *C. pallipes*, Waltl, was evidently supplied by Meigen, and amplified by him in 1838. The British Museum possesses a copy of Meigen's Abbildung eur. zweifl. Ins., hand-coloured by the author, in which the figure of *C. rufus* evidently represents *C. pipiens*, though the venation is shown in a conventional manner.* In his diagnosis of *C. meridionalis*, Leach says " abdomine segmentis omnibus postice griseo marginatis," but as he makes a similar statement regarding his *C. nicaensis* and *C. musicus*, it seems probable that by " postice " he meant " basally." Ficalbi's description of *C. phytophagus*, especially as regards the male palpi and abdominal bands, shows that he had *C. pipiens*, not *C. laticinctus* or *C. univittatus*, before him. I have examined the types of *C. marginalis*, *C. agilis*, *C. varioannulatus*, and *C. azoriensis*, and find them to be *C. pipiens*. Dr. Dyar informs me that he has examined Coquillett's type of *C. pallens*, and that it is *C. pipiens*. The species has frequently been referred to as *C. ciliaris*, L., but I think probably incorrectly.

Distribution.—Throughout the Palaearctic region ; also in parts of North and South America, East and South Africa, and Madagascar ; no doubt spread by commerce.

* It may also be remarked here that the figures in this work of *C. vexans* and *C. annulipes* agree with the interpretation of these names adopted in this paper. Some of the other figures are less decisive.

Bibliography.

The following list includes only the more important of the works dealing with Palaearctic CULICIDAE from the entomological point of view; purely economic works, as well as obsolete systematic papers, are not included. A fairly full bibliography, up to the end of 1919, is given by Martini in "Ueber Stechmücken."

BARRAUD, P. J. Notes on some Culicidae collected in Lower Mesopotamia.—Bull. Ent. Res. x, 1920, pp. 323–325.

——. Mosquitos collected in Palestine and adjacent territories.—Bull. Ent. Res. xi, 1921, pp. 387–395.

BLACKLOCK, B. and CARTER, H. F. Observations on *Anopheles* (*Coelodiazesis*) *plumbeus*, Stephens, with special reference to its breeding-places, occurrence in the Liverpool district, and possible connection with the spread of malaria.—Ann. Trop. Med. xiii, 1920, pp. 413–446, pls. x–xii.

BROLEMANN, H. W. Sur quelques *Culex* de Pyrénées et description d'une éspèce nouvelle.—Ann. Soc. Ent. France, lxxxvii, 1918, pp. 425–440; lxxxviii, 1919, pp. 65–103; lxxxix, 1920, pp. 51–73. (Includes good figures of the male hypopygia of most of the species found in France.)

CARTER, H. F. Descriptions of the male genital armatures of the British Anopheline mosquitoes.—Ann. Trop. Med. xiii, 1920, pp. 453–457 figs.

CHRISTOPHERS, S. R. The male genitalia of Anopheles.—Ind. J. Med. Res. iii, 1915, pp. 371–394, pls. xx–xxv.

——. Notes on some Anophelines from Arabia and Mesopotamia.—Ind. J. Med. Res. iii, 1915, pp. 180–200, pl. xvi.

——. Recent observations on the Anopheles of the Middle East.—Ind. J. Med. Res. vii, 1920, pp. 710–716, 3 maps.

——— and SHORTT, H. E. Malaria in Mesopotamia.—Ind. J. Med. Res. viii, 1921, pp. 508–552.

ECKSTEIN, F. Zur Systematik der einheimischen Stechmücken—Centralbl. f. Bakt., Parasit. u. Inf.-Krankh., 1 Abt., lxxxii, 1918, pp. 57–68, figs. (females); lxxxiii, 1919, pp. 281–294, figs. (larvae); lxxxiv, 1920, pp. 223–240, figs. (males).

——. Die einheimischen Stechmücken. Eine Schilderung ihrer Lebensweise und anleitung zu ihrer Bestimmung, Mit 17 Abbild.—Wiss. Mitglied des Forschungsinst. f. angew. Zool. Berlin, 1920, 58 pp. (Largely a reprint of above series of papers, with some biological and other details added.)

FICALBI, E. Revisione delle specie europee della fam. delle Zanzare.—Bull. Soc. Ent. Ital. xxiv, 1892, pp. 257–284; xxv, 1893, pp. 48–61, 136–144; xxvi, 1894, pp. 66–75, 315–320; xxvii, 1895, pp. 29–38; xxviii, 1896, pp. 108–313, pls. i–v. (The earlier sections include quotations of the original descriptions of all European species then known.)

——. Venti specie di Zanzare (Culicidae) Italiane.—Bull. Soc. Ent. Ital. xxxi, 1899, pp. 46–234, figs.

FOLEY, H. Etude morphologique de *Pyretophorus chaudoyei* Théob., aux differents stades de son evolution.—Campagne antipaludique de 1911, Alger, 1912, pp. 49–50, pls. iii–v.

GALLI-VALERIO, B. Sechzehn Jahre Untersuchungen über Kuliziden und Malaria.—Arch. Schiffs. Hyg. xxii, 1918, pp. 154–158. (Briefly summarises the author's work, with bibliography of his 45 short papers.)

GOETGHEBUER, M. Culicides et Corethrides de Belgique.—Ann. Soc. Ent. Belg. 1910, pp. 81–87, 410–412.

JOYEUX, C. Note sur les Culicides de Macédoine.—Bull. Soc. Path. Exot. II, 1918, pp. 530–547.

LANG, W. D. Handbook of British Mosquitoes.—London, British Museum (Natural History), 1920.

LANGERON, M. Remarques sur les larves du *Culex geniculatus* et sur les larves de Culicinés pourvues d'un long siphon.—Bull. Soc. Path. Exot. ix, 1916, pp. 438–442, figs.

——. Remarques sur l'évolution larvaire de *Theobaldia annulata* (Schrank, 1776).—Bull. Soc. Path. Exot. ix, 1916, pp. 703–708, figs.

——. Morphologie et biologie de la larve de *Theobaldia spathipalpis*, Rondani, 1872.—Bull. Soc. Path. Exot. xi, 1918, pp. 98–103, figs.

——. La larve d' *Anopheles chaudoyei* (Theobald, 1903).—Bull. Soc. Path. Exot. xi, 1918, pp. 291–297, figs.

LEON, N. Studii asupra Culicidelor din România.—Bucuresti, 1910, Directiunea Generale a serviciului sanitar. Pp. 274, pls. xv, figs. 111.

——. Contributions à l'étude des Culicides de Roumanie.—Centralbl. f. Bakt. liii, 1910, pp. 499–505.

MARTINI, E. Über Stechmücken, besonders deren europäische Arten und ihre Bekämpfung.—Archiv f. Schiffs- und Tropenhyg. Band 24, Beiheft 1, 1920, pp. 1–267, pls. i–iv, 117 text figs.

——. Die biologische Malariabekämpfung in Mazedonien.—Zeitschr. f. Angew. Ent. vii, 1921, pp. 225–286.

DE MEIJERE, J. C. H. Zur Kenntnis niederländischer Culiciden.—Tijd. v. Ent. liv, 1911, pp. 137–157, pls. viii–x.

NUTTALL, G. F. H. and SHIPLEY, A. E. The structure and biology of *Anopheles*.—Journ. Hyg. I, 1901, pp. 45–77, 269–276, 451–482, pls. i, ii, viii–x; II, 1902, pp. 58–84, 166–215, pls. vi–viii.

SCHNEIDER, P. Beitrag zur Kenntnis der Culiciden in der Umgebung von Bonn.—Verh. Nat. Ver. Preuss. Rheinl. u. Westf. lxx, 1914, pp. 1–54, 2 pls.

SÉGUY, E. Les moustiques de France.—Bull. Mus. d'Hist. Nat. Paris, 1920, pp. 51–58, 141–149, 223–230, 322–329, 407–414, 512–519.

——. Remarques sur quelques larves de moustiques.—Bull. Soc. Ent. Fr. 1920, pp. 309–311.

——. Note sur l'armure génitale du *Culex jugorum* Villen.—Bull. Soc. Ent. Fr. 1921, pp. 39–40.

SERGENT, Ed. et Et. Observations sur les moustiques des environs d'Alger.—Ann. Inst. Pasteur, xvii, 1903, p. 60.

——. Observations sur les Anopheles d'Algerie.—Ann. Inst. Pasteur, xix, 1905, p. 144, and xx, 1906, p. 393.

STOREY, G. Keys for the determination of Egyptian Mosquitoes and their larvae.—Bull. Soc. Ent. Egypte, Cairo, 1918 (1919), pp. 84–106, 2 pls.

VASSILIEV, J. B. *Cellia pulcherrima*, Theo., und einige neue Angaben über Erscheinen und Überwintern von *Anopheles bifurcatus*, L., in Turkestan. (See Rev. App. Ent. i, p. 193.)

WATERSTON, J. On the mosquitos of Macedonia.—Bull. Ent. Res. ix, 1918, pp. 1–12.

WESENBERG-LUND, C. Anatomical description of the larva of *Mansonia richardii* (Ficalbi) found in Danish freshwaters.—Vidensk. Medd. Dansk. naturhist. Forn. lxix, 1918, pp. 277–328, figs.

—. Contributions to the biology of the Danish Culicidae.—D. Kgl. Danske Vidensk. Selsk. Skrifter, Nat. Math. Afd., 8 Raekke, vii, 1921, pp. 1–210, pls. i–xxi.

Index of Specific and Varietal Names applied to Palaearctic Mosquitos.

(Synonyms and unrecognisable names in *italics*.)

abfitchii, Felt 305
aegypti, L. 325
affinis, Steph. 288
agilis, Big. 345
alaskaensis, Ludl. .. 288
albescens, sp. n. .. 308
albionensis, Macgr. .. 290
albolateralis, Theo. .. 318
albopalposus, Becker .. 325
albopictus, Skuse .. 325
albopunctatus, Rond. .. 319
algeriensis, Theo. .. 270
alineata, Schn. 313
alpinus, L. 309
angustealatus, Becker .. 325
annulatus, de Fourc. .. 288
annulatus, F. 288
annulatus, Schrank. .. 288
annulipes, Mg. 305
antennatus, Becker .. 271
apicalis, Adams .. 336
arabica, Giles 299
arabicus, Becker .. 299
arabiensis, Patton (*A*) .. 277
arabiensis, Patton (*C*) .. 322
arcanus, Blanch. .. 307
arctica, Edw. 288
articulatus, Rond. .. 322
azoriensis, Theo. .. 346

bambusa, Yam. .. 284
bergrothi, Edw. 287
bicolor, Mg. 345
bifurcatus, L. 271
bimaculata, Leic. .. 283
bipunctatus, R.-D. .. 307
bitaeniorhynchus, Giles 337
broquettii, Theo. .. 300

calcitrans, R.-D. .. 345
calopus, Mg. 325
cantans, Mg. 304
cardamitisi, Newst. .. 278
caspius, Pallas 299
cataphylla, Dyar .. 310
chaudoyei, Theo. .. 280
christophi, Port. .. 285
ciliaris, L. 323
cinereus, Mg. 323
claviger, F. 272
claviger, Mg. 271
cleopatrae, Willcocks .. 280
communis, Deg. .. 314
concinnus, Steph. .. 312
costalis, Theo. 277
creticus, Theo. 339
cretinus, sp. n. 325
curriei, Coq. 300
cyprius, Ludl. 307

detritus, Hal. 310
diantaeus, H.D.K. .. 311
diplolineata, Schn. .. 315
diversus, Theo. 308
doliorum, Edw. .. 346
domesticus, Germar .. 345
dorsalis, Mg. 300
dorsovittatus, Villen. .. 312
d'thali, Patton 278

eatoni, Edw. 319
echinus, Edw. 320
elegans, Fic. 325
elutus, sp. n. 273
excrucians, Walk. .. 305

fatigans, Wied. 345
fasciatus, F. 325
fasciatus, Mg. 314
fasciatus, Müller .. 345
ficalbii, Noé 290
flavescens, F. 307
flavescens, Müller .. 306
flavescens, Theo. .. 307
flavirostris, Mg. .. 289
flavovirens, R.-D. .. 267
flavus, Motch. 307
flerowii, Portch. .. 267
fletcheri, Coq. 307
freyi, sp. n. 306
fumipennis, Steph. .. 290
fusculus, Zett. 319

gallii, Mart. 316
geniculatus, Ol. 319
glaphyropterus, Schin. 287
grahami, Ludl. 300
grisescens, Steph. .. 271
guttatus, Curt. 319

haematophagus, Fic. .. 345
haplolineata, Schn. .. 313
hargreavesi, Edw. .. 300
hayashi, Yam. 336
hispaniola, Theo. .. 279
hortensis, Fic. 336
hyrcanus, Pall. 274

impiger, Walk. 316
impudicus, Fic. .. 335
impunctus, Dön. .. 280
innuitus, D. & K. .. 309
intrudens, Dyar .. 316

japonicus, Theo. .. 318
jugorum, Villen. .. 316

konoupi, Brullé .. 325
koreicus, Edw. 318

lateralis, Mg. .. 311, 319
laticinctus, Edw. .. 342
laurenti, Newst. .. 344
lepidonotus, Edw. .. 308
lesnei, Séguy 312
leucacanthus, Lw. .. 303
leucogrammus, Lw. .. 299
leucomelas, Mg. 314
leucopygus, Eysell. .. 323
lewisi, Ludl. 272
lindesayi, Giles 273
longiareolatus, Macq. .. 287
longifurcatus, Beck. .. 345
longisquamosa, Theo. .. 299
lukisi, Chr. 270
luteovittatus, Theo. .. 308
lutescens, F. 306
luteus, Mg. 345

macedoniensis, C. & H. .. 278
maculatus, Mg. 304
maculicosta, Beck. .. 277
maculipennis, Mg. .. 272
maculiventris, Mcq. .. 300
malariae, Grassi .. 322
marginalis, Stph. .. 345
mariae, Serg. 303
maroccanus, d'Anfr. .. 287
mauritianus, Grp. .. 275
meigenanus, Dyar .. 313
melanorhinus, Giles .. 345
meridionalis, Leach .. 345
mesopotamiae, Chr. .. 274
metallepticus, Dyar .. 316
mimeticus, Noé 337
modestus, Fic. 332
molestus, Forsk. .. 345
morsitans, Theo. .. 289
multicolor, Camb. .. 280
musicus, Leach .. 308
myzomyfacies, Theo. .. 279

nearcticus, Dyar .. 309
nebulosus, Theo. .. 335
nemorosus, Mg. .. 313, 314
nicaensis, Leach. .. 288
nigrina, Eckst. 312
nigripes, Staeg. .. 271
nigripes, Zett. 309
nigritulus, Zett. .. 323
nigritulus, W.-L. .. 347
niveus, Eichw. 325
niveus, Ludl. 318
nursei, Theo. 278

obscurus, Mg. 315
obturbans, Walk .. 326
occidentalis, D. & K. .. 272
onondagensis, Coq. .. 300
orientalis, sp. n. .. 338
ornatus, Mg. 319
osakensis, Theo. .. 346

	Page
pallens, Coq.	346
palestinensis, Theo.	278
pallipes, Mcq.	345
pallipes, Mg.	345
pallipes, Waltl.	345
palmeni, Edw.	315
paludis, Theo.	275
parvulus, sp. n.	314
parvus, Mcq.	322
penetrans, R.-D.	289
penicillaris, Rond.	299
perexiguus, Theo.	342
persicus, var. n.	280
pharoensis, Theo.	277
phytophagus, Fic.	345
pictus, Lw.	274
pilifera, Theo.	336
pipiens, L.	345
plumbeus, Steph.	271
prodotes, Dyar	310
pseudonivea, Theo.	318
pseudopictus, Grassi	274
pulcherrimus, Theo.	277
pulchripalpis, Rond.	290
pulchritarsis, Rond.	303
pullatus, Coq.	316
punctatus, Mg.	299
punctibasis, sp. n.	274
punctor, Kirby	313
pungens, R.-D.	308
pusillus, Macq.	333
pyrenaicus, Brolem.	336
quadratimaculatus, Macq.	308
quartus, Mart.	305
quasigelidus, Theo.	337
quasimodestus, Theo.	346
quinquefasciatus, H.D.&K.	345
reptans, Mg.	315
rhodesiensis, Theo.	278
richiardii, Fic.	291
rostochiensis, Mart.	310
rufinus, Big.	345
rufus, Mg.	345
rufus, Gimm.	323
rusticus, Rossi	308
sacharovii, A.	267
salinellus, Edw.	311
salinus, Fic.	310
scutellaris, Theo.	325
selengensis, Ludl.	272
semicantans, Mart.	305
sergenti, Theo. (*A*)	279
sergenti, Theo. (*C*)	336
serratipes, Beck.	287
serus, Mart.	311
siberiensis, Ludl.	288
siculus, R.-D.	299
sinensis, Theo.	337
sinensis, Wied.	274
spathipalpis, Rond.	287
stephensi, Liston	277
sticticus, Mg.	311
subalbatus, Coq.	326
subochrea, Edw.	289
subtilis, Serg.	299
sugens, Theo.	325
superpictus, Grassi	278
surcoufi, Theo.	305
sylvae, Theo.	312
sylvaticus, Mg.	315
terriei, Theo.	310, 311
territans, H. D. K.	336
theobaldi, Meij.	290
thoracicus, R.-D.	345
tipuliformis, Theo.	339
titillans, Leon	291
togoi, Theo.	318
towadensis, Mats.	285
trifurcatus, F.	271
tritaeniorhynchus, Giles	339
unguiculata, Edw.	283
univittatus, Theo.	342
variegatus, Schrank.	288, 306
varioannulatus, Theo.	346
vassilievi, Portch.	267
vexans, Mg.	322
villosus, R.-D.	271
virgatipes, Edw.	341
viridis, R.-D.	267
vishnui, Theo.	339
vittatus, Big.	325
vorax, sp. n.	327
vulgaris, L.	267
waterhousei, Theo.	304
willcocksi, Theo.	299
zammtitii, Theo.	303

AGRILUS FOVEICOLLIS, MARS., AS A CAUSE OF THE DECAY OF THE CULTURE OF ROSES IN BULGARIA.

By Prof. S. A. Mokrzecki.

Experimental Agricultural Institute, Sofia.

During the months of May and June 1921 I investigated the cause of the serious losses that had occurred among the rose-trees (especially *Rosa damascena*, Mill.) which are extensively grown in Bulgaria for making attar of roses. The conclusion arrived at is that the cause of the general decline in rose culture is inadequate

Galls on stems of *Rosa damascena*, caused by the larvae of *Agrilus foveicollis*, Mars.—1, One-year-old shoot; the bark is cut off and the burrows of the three to four days' old larva may be seen; no swelling is formed yet. 2, Two-year-old shoot, with a swelling near its base; the top of the shoot was beginning to dry up. 3, Two-year-old shoot, with the swelling cut open; several annular passages are clearly visible. 4, Three-year-old shoot, on which the swelling is very distinct; by this time the majority of the small branches had already faded. All photographs taken from nature and slightly enlarged.

nourishment of the plants, owing to an insufficient amount of humus and nitrogen in the soil, aggravated by the entire neglect of manuring by the growers. But the immediate cause of the death of thousands of rose-bushes has proved to be certain galls that are to be found on the stems, reaching 2–3 cm. in length and sometimes twice as thick as the normal stem.

When the gall is cut open, dark-coloured burrows may be seen circling the stem just under the bark, the number varying from three to fourteen. Up till now, however, no insects have ever been found in these galls, and previous investigators attributed them to *Agrilus viridis*, L.* Injuries of this kind have been also recorded on roses in Italy† and France,‡ and Houard§ attributes them to the activity of larvae of some Microlepidopteron.

My investigations have led me to the conclusion that the galls are caused by the larvae of *Agrilus foveicollis*, Mars.,‖ a species described from Siberia and never recorded previously from any locality in Europe.

The life-cycle of this new and very destructive pest of roses is not quite clear, but the following points have been actually observed by myself. The beetles appear in the middle of May and live on the leaves of roses, nibbling their margins. The female, after copulation, lays her eggs, up to 30 in number, each separately, under the bark of one-year-old shoots. Each egg is laid in a scarcely perceptible oblong hole, made by the ovipositor ; it is about 0·3–0·4 mm. long, white, with the surface covered with a network of fine furrows. The eggs hatch after 5–7 days, and even during the first 2–3 days of its life the larva may make as many as three annular burrows around the shoot, under the bark, filled with black excrement. No swelling, however, is formed during the first summer (fig. 1). In the second year the swelling is noticeable and increases gradually (figs. 2 and 3), while the infested shoot begins to dry up. In the third year the whole stem gradually dies (fig. 4).

The life of the larva lasts apparently about one year, and that is why larvae are not to be found in the galls which are already well formed. There may be several galls on the same stem.

---

* Dr. Nikoloff, M. Stefanoff and N. Pouchkareff : " The Culture of Roses in Bulgaria," Revue d'Inst. des Recherches agronomiques en Bulgarie, i, nos. 5 & 6, 1921, pp. 11–14 (in Bulgarian). There is a figure of *A. viridis*, L., and its larva and cocoon, with descriptions taken from Richter von Binnenthal's book: " Die Rosenschädlinge aus dem Tierreiche," Stuttgart (1903), as well as original figures of the burrows as observed by the authors in Bulgaria.

† Del Guercio, " Intorno ad una deformazione del fusto della Rosa in Italia."—Nuove Relaz. Staz. Entom. Agr. Firenze, pp. 143–146, pl. ix, figs. 1–2.

‡ J. Beauderie, " Les Croussins du Rosier."—Hort. Nouv. Lyon, 1911.

§ " Les Zoocecidies des plantes d'Europe," i, p. 542.

‖ Coleopt. Hefte, v, 1869. I am much indebted for the identification of my specimens to the Imperial Bureau of Entomology and to its Director, Dr. G. A. K. Marshall.

NOTES ON A COLOUR TROPISM OF *ASTEROCHITON* (*ALEURODES*) *VAPORARORIUM*, WESTWOOD.

By Ll. Lloyd, D.Sc. (Leeds).

During 1919–20 an investigation into the habits of *Asterochiton* (*Aleurodes*) *vaporariorum*, Westw., was being carried out at the Lea Valley Experimental Station, Cheshunt, with a view to controlling its attacks on tomatoes under glass. The station exists for the study of scientific problems connected with the glasshouse industry, and as the staff is small, the work is necessarily confined to strictly economic lines. Points that appear in the course of the investigations cannot be followed to their ultimate conclusion in these earlier years of the station's existence if they seem to be of theoretical rather than of practical importance. The following notes relate to such a problem, which it has been decided to record, though in a very unfinished state.

A habit of this whitefly of settling upon clothing led to a short study of its colour reactions. All the experiments were carried out in a heated greenhouse in December and January. A wooden cage was used, 18 in. by 18 in. by 24 in. high, with the bottom six inches forming a wooden well, and above this four sides and a roof of muslin. An exactly similar wooden framework without the muslin was also employed, its sides and roof being open to the greenhouse.

Experiments with Transmitted Light.

Various weak solutions in water of substances conveniently to hand were made up. Clear white glass corked tubes one inch in diameter and three in length were filled with the solutions to a depth of one and a half inches, and the outsides of the tubes to the same depth were thinly smeared with a clear adhesive composed of resin and castor oil. The tubes were then hung by strings around the four sides of the frame so that they were equidistant from each other and about fifteen inches from the centre of the well. Cut infested foliage was placed in the floor of the well. During the tests the positions of the tubes were interchanged, the least attractive to the position of the most attractive, and so on, or the whole frame was revolved through 90°. The insects were removed by means of a needle and counted at intervals of from one hour to two days.

Experiment 5.

December 3rd; bright sun; exposure, seven hours of daylight. Twelve weak solutions were made up at random to give a wide range of colours; 452 flies were trapped, and their distribution is shown in diagram 1 by the continuous line. The following solutions were attractive in order of merit: light yellowish-green (picric acid+jodgrün), fluorescent (weak cosin), greenish-yellow (picric acid), orange (orange G.). The following gave negative results: water, bright red (fuchsin), blood red (Congo red), blue-green (methyl green), pale blue (methylene blue), indigo (nachtblau) and violet (gentian).

Experiment 6.

December 5th–6th; dull; exposure 16 hours' daylight. Solutions as above, with three others added; 266 flies were trapped, and their distribution is shown in diagram 1 by the broken line. The same solutions as in the last experiment, together with purple (potassium permanganate), proved negative. The eosin solution was only moderately attractive, and a strong solution of potassium bichromate rather

less so, but a weak solution of the same substance was the most attractive in the test, trapping nearly a quarter of the total flies caught.

It was evident from these and from other crude tests that the attractive solutions all had a predominating yellow colour, or were fluorescent. The next experiments were carried out in an endeavour to find an optimum attraction.

Experiment 9.

December 9th -15th ; little weak sunlight ; exposure 56 hours' daylight. Solutions of potassium bichromate (yellow fluorescent) of percentage strengths 5, 1, $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{64}$, $\frac{1}{256}$, two tubes of each ; 1,771 flies were trapped, and their distribution is shown in diagram 2. The optimum strength for this solution was clearly from $\frac{1}{4}$ to $\frac{1}{16}$ per cent., from the nature of the curve between these two ; $\frac{1}{8}$ per cent. potassium bichromate was therefore used as a standard in the next experiment.

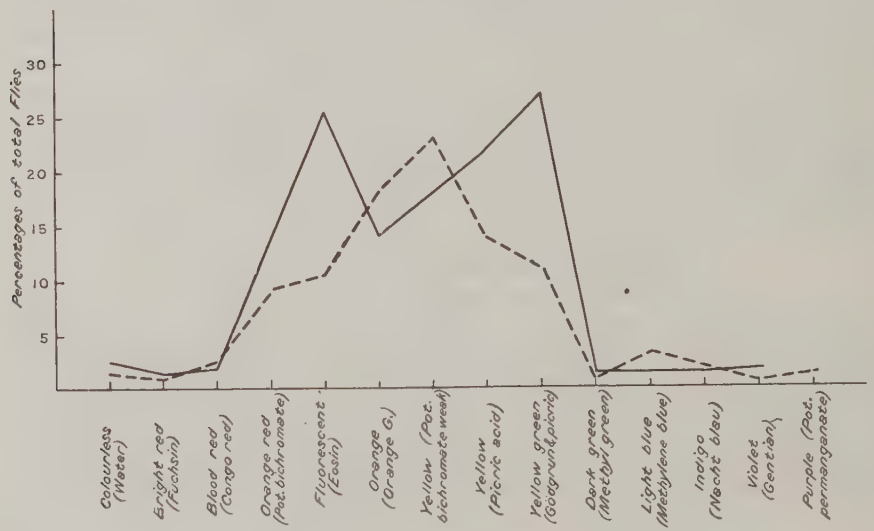

Diagram 1. (See Experiments 5 and 6.)

Experiment 10.

December 16th–20th ; little weak sunlight ; exposure 40 hours of daylight. Four solutions of orange G. of strengths $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{128}$, and $\frac{1}{512}$ per cent., and four of eosin of strengths $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{64}$, and $\frac{1}{256}$ per cent., one tube of each, were tested against four control tubes of $\frac{1}{8}$ per cent. potassium bichromate ; 983 flies were trapped, and had the distribution shown in diagram 3. The eosin solutions were relatively unattractive, but the nature of the curve shows that there was some attraction, the optimum strength being about $\frac{1}{128}$ per cent. It may be pointed out that the occasion when the attraction of this substance was powerful was when tested in bright sunlight, its other tests being all in dull weather with intermittent weak sun. The solutions of orange G. were less attractive than the control except the $\frac{1}{128}$ per cent. solution, which drew 60 per cent. more flies. In the course of the experiment three counts were made on the twelve tubes, and this tube trapped most flies in each case, except that it was bettered once by a control, 53 as against 42. An attempt was made to analyse the maximum point on the orange G. curve in the next experiment.

Experiment 12.

December 20th–23rd ; little weak sunlight ; 32 hours' daylight. Three strengths of orange G., $\frac{1}{64}$, $\frac{1}{128}$, $\frac{1}{256}$ per cent., four tubes of each ; 849 flies were trapped as follows : $\frac{1}{64}$ per cent., 257 flies (30 per cent.) ; $\frac{1}{128}$ per cent., 274 flies (32 per cent.) ; $\frac{1}{256}$ per cent. 318 flies (37 per cent.). This is not a decisive result, although the figures appear to be graded, the differences being within the range of experimental error and rather erratic in the separate counts.

The solution which drew forth the greatest response was thus one of orange G., of a strength approximating to $\frac{1}{128}$ per cent.

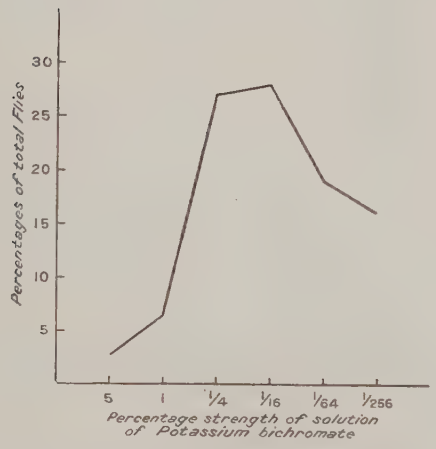

Diagram 2. (See Experiment 9.)

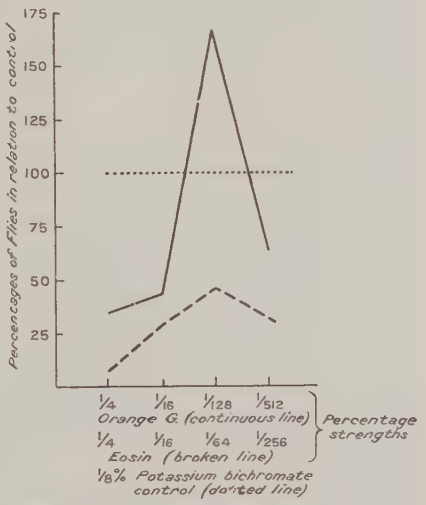

Diagram 3. (See Experiment 10.)

Experiments with Reflected Light.

Experiment 3.

December 2nd ; a strip of white card, seven inches long and one and a half inches broad, was divided by transverse lines into seven equal sections, and these were painted with water-colour washes in the following order : red, orange, yellow, green, blue, indigo, violet. When dry this was lightly smeared with a transparent adhesive and placed horizontally in the cage one foot above the bottom of the well, which contained infested foliage. The flies left the foliage and flew to the top of the cage, and were then in a position to see the trap. The card was exposed for two hours, the sun being bright. At the end of the first hour the card was turned, to reverse the position of the colours. In all, 397 flies were trapped, and their distribution is shown in diagram 4. Orange, green and yellow proved attractive, the last-named trapping 51 per cent. of the total. The four remaining colours held only about 10 per cent. of the total catch.

Experiment 11.

December 19th–20th ; a small tomato leaf one and a half inches long was taken, and six pieces of paper of the same size and shape were washed with water-colours as follows : red, orange, yellow, yellowish-green, blue and white. Each of these

was then fastened in sandwich manner between a pair of white glass microscope slides and the upper one was lightly smeared with adhesive. These were placed in the cage as described above and their positions were interchanged twice, counts being made each time. The total exposure was four hours, with the sun shining brightly; 1,041 flies were caught, and their distribution is shown in diagram 5. Yellow trapped 60 per cent. of the total; the yellowish-green was attractive, and the tomato leaf less so. Red, blue, white, and in this case orange also, gave negative results.

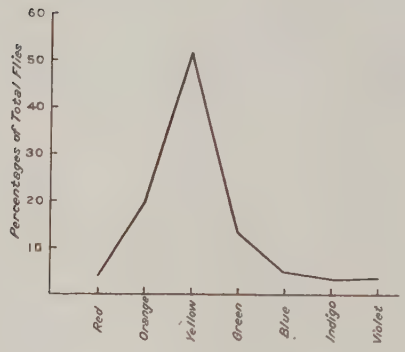

Diagram 4. (See Experiment 3.)

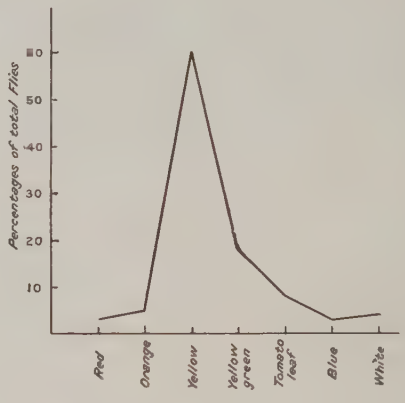

Diagram 5. (See Experiment 11.)

The large numbers trapped in these short exposures by the opaque yellow, compared with the numbers trapped by the yellow solutions, suggests that the former is more attractive, and the following experiments seem to confirm this.

Experiment 13.

December 22nd–29th; five glass tubes twelve inches long and half an inch in diameter were taken. Four were filled with a solution of $\frac{1}{64}$ per cent. orange G., which in a column of this diameter appeared to have the same tint as the $\frac{1}{128}$ per cent. solution in a one inch column. The fifth tube was lined with yellow paper. All were smeared with adhesive and suspended around an infested tomato plant ten inches high on staging in the greenhouse. The clear tubes trapped 178 flies, an average of 44 each, and the opaque one 91. At the end of the experiment there remained on the plant 17 flies only.

The relative attractions of tomato foliage and a yellow surface are shown in the following experiments.

Experiment 14.

December 23rd–31st; a sheet of yellow paper, 7 in. by 8 in., was sandwiched between two sheets of glass of the same size and the trap was coated with adhesive on both sides. This was then suspended vertically facing north and south, and a lightly infested tomato plant about one foot in height was placed on each side of it at a distance of a foot. A third similarly infested tomato plant was placed at a distance of six feet. All the plants were recently infested, and no flies emerged on them during the course of the experiment. There were, however, a number of infested plants in the greenhouse on which flies were emerging, and these had access to the three plants and the trap. Eight days after the experiment had been set up the plant to the north held 33 flies and the north side of the trap 602, the plant to the south

held 21 and the south side of the trap 470. The distant plant held 122 flies. The trap was now removed, and ten days later the two plants which were near it and were kept in the same position held 80 and 133 flies respectively, no emergence having occurred upon them and the source of invading flies remaining approximately the same as when the trap was exposed.

Experiment 16.

January 8th; the main source of flies was a nettle plant growing in a pot and massively infested. A small uninfested tomato plant one foot in height was placed at a distance of two feet and the tube lined with yellow paper, as described in experiment 13 above, was stuck into the soil of the pot holding the tomato. After four-and-a-half hours of moderate sunlight a count of the flies was made. The tomato plant with a total foliage area (both surfaces of leaves) of 120 sq. in. held 106 flies, about one to the square inch, and the trap with an area of 14 sq. in. held 160 flies, or about 11 to the square inch.

Conclusions.

Both sexes of the insect were drawn to the yellow traps, so the habit is probably not associated with mating. The bodies of the mature insects are yellow and the scale has a large internal organ of a yellow colour, the mycetoma, which is conspicuous in the younger scales. The insect is distinctly gregarious, quite apart from the fact that it seeks younger foliage, and sometimes the majority of the flies on a plant are found gathered on one or two leaves. It appeared possible that this gregarious habit was at the root of the attraction, and a number of adults were enclosed in a glass tube. This and an empty tube were smeared with tanglefoot and placed in the cage. The tube of fly caught 28 and the empty tube 25 in eight hours' exposure. There was clearly no definite attraction here, and it is probable that the yellow body of the insect is not sufficiently conspicuous to be perceived.

Several manifestations of the phenomenon were observed apart from the experiments recounted. The attraction to clothing, and especially to the khaki garments which were commonly worn by the tomato hands at this time, has been referred to. The flies may often be seen on yellow flowers. It was noticed particularly that the yellow flowers of narcissus were more favoured than the foliage of the plant, and many eggs were laid on them, though these inevitably perished. In the autumn, when heavily infested tomato houses were being cleared out in the neighbourhood, and the air in places was full of the disturbed insects, great numbers were seen hovering over yellow privet, but the insect does not care for leathery foliage and has not been known to breed on this shrub.

The most favoured foods of the insect out of doors in England are the following plants:—hollyhock, calceolaria, tobacco, sunflower, French and runner beans, and vegetable marrow. All these have a distinctly yellowish-green foliage. The colour attraction is believed to be associated with choice of food and to draw the migrating insects to light-foliaged plants as opposed to those which have dark leaves; but for the reason given, the elaborate experiments which would be necessary to prove this could not be undertaken. It is possible also that a solution of the problem could only be found by studying the insect in its native haunt, which is said to be Brazil.

It might be possible to devise some method of partial check to the pest by means of these traps. Literally enormous numbers can be caught on a yellow screen by shaking infested plants and holding the screen near them. The flies fly up when disturbed in this way and pass to the screen as though drawn by a magnetic force. Any such method of check would be clumsy and is not worth elaboration, since perfect control of the pest can be obtained in the greenhouses by fumigations with hydrocyanic acid, and out of doors, in England at any rate, the insect is not a pest of major importance, and can only rarely be considered a pest at all.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. M. Aders, Government Economic Biologist :—75 Culicidae, 53 Hippoboscidae, 4 other Diptera, and 6 Coleoptera ; from Zanzibar.

Mr. E. Ballard, Government Entomologist :—7 Ants and 157 Rhynchota ; from South India.

Mr. C. F. C. Beeson, Forest Zoologist :—28 Braconidae and 47 Curculionidae from India.

Mr. G. E. Bodkin, Government Economic Biologist :—77 Culicidae, 1 *Tabanus*, 4 Hymenoptera, and 1 Beetle ; from British Guiana.

Prof. C. K. Brain :—4 Culicidae, 3 *Haematopota*, 25 other Diptera, 105 Coleoptera, 41 Rhynchota, and 101 Orthoptera ; from Stellenbosch, South Africa.

Mr. P. A. Buxton : –58 Diptera, 14 Hymenoptera, 50 Coleoptera, 6 Rhynchota and 81 Orthoptera ; from Palestine.

Prof. T. D. A. Cockerell :—28 species of Coccidae ; from Colorado.

Mr. J. B. Corporaal, Entomologist, Algemeen Proefstation, Medan :—8 Rhynchota ; from Sumatra.

Mr. R. Cottam :—12 Cockroaches ; from the Anglo-Egyptian Sudan.

Department of Agriculture, Bangalore :—64 Coleoptera ; from India.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—232 Coleoptera, and 1,505 Orthoptera ; from India.

Mr. E. Cresswell-George :—4 Coleoptera and 4 Orthoptera ; from Nyasaland.

Mr. C. C. Gowdey, Government Entomologist :—8 *Lyperosia*, 1 *Stomoxys*, 6 Hymenoptera, 16 Coleoptera, 42 Lepidoptera, 5 species of Aphididae, 12 species of Coccidae, 25 other Rhynchota, and 1 Dragonfly ; from Jamaica.

Mr. C. B. Hardenberg, Chief Entomologist, Department of Agriculture :—1,268 Coleoptera ; from Portuguese East Africa.

Mr. H. Hargreaves, Government Entomologist :—2 Hippoboscidae, 53 other Diptera, 37 Siphonaptera, 411 Hymenoptera, 118 Coleoptera, 600 Thysanoptera, 15 Lepidoptera, 24 species of Coccidae, 76 other Rhynchota, 1 Acridiid, 70 Anoplura, 14 Mites, 64 Ticks, 3 Spiders, and 2 Pseudoscorpions ; from Uganda.

Hawaiian Sugar Planters' Association :—36 Coleoptera ; from Honolulu : and 66 Curculionidae and 4 microscope preparations ; from Australia.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—64 Culicidae and 4 Tabanidae ; from Australia.

Dr. A. Ingram :—21 Tubes containing 700 minute Diptera ; from the Gold Coast.

Dr. W. B. Johnson :—5 Culicidae, 1 *Chrysops*, 3 *Hippocentrum*, 71 *Haematopota*, 11 *Tabanus*, 25 *Glossina*, 3 pupa cases, and a species of Mite attacking *Glossina* ; from Northern Province, Nigeria.

Mr. H. H. King, Government Entomologist :—13 Gryllid nymphs associated with Ants, 3,513 Ants and a number of early stages ; from the Anglo-Egyptian Sudan.

Dr. W. A. Lamborn :—980 Culicidae and 30 other Diptera ; from China and Japan.

Rev. T. P. Levett :—2 Chalcididae ; from Richmond, Yorkshire.

Dr. J. W. Scott Macfie : —282 Culicidae, 19 Psychodidae, 1 *Tabanus*, 1 *Glossina*, 1 Asilid and prey, 700 other Diptera, 10 Ants, 12 other Hymenoptera, 18 Coleoptera, 34 Lepidoptera, 2 species of Coccidae, 101 other Rhynchota, 8 Cockroaches and 1 nymph, 16 Planipennia, 1 Dragonfly, 6 Anoplura, 2 Spiders, a number of Mites, 2 Scorpions and young, and 2 small Snakes ; from Accra, Gold Coast.

Mr. C. W. Mally, Senior Entomologist, Department of Agriculture, Cape Town :— 5 Curculionidae ; from South Africa.

Mr. G. E. Mellor :—2 Wasps ; from the Anglo-Egyptian Sudan.

Ministry of Agriculture, Egypt :—41 Hymenoptera, 98 Coleoptera, 1 Moth, 1 Reduviid bug, and 3 Orthoptera ; from Egypt.

Prof. S. A. Mokrzecki :—8 Agrilidae ; from Bulgaria.

Mr. J. C. Moulton :—49 Coleoptera, 1 Pentatomid bug, and 17 Orthoptera ; from Singapore.

Dr. L. Péringuey, Director, South African Museum :—94 Coleoptera ; from South Africa.

Senhor A. F. de Seabra :—18 Coleoptera, 9 Lepidoptera, and 1 Ascalaphid ; from San Thomé.

Mr. H. W. Simmonds :—1 *Tabanus*, 25 other Diptera, 21 Hymenoptera, 8 Coleoptera, 10 Lepidoptera, 11 Lepidopterous pupa cases, 1 Caddisfly, 2 species of Coccidae, 2 other Rhynchota, 1 Cricket, 1 Haemerobiid, 2 Spiders, 5 Mites, and 1 Micro-slide of Nematode eggs ; from Fiji.

Dr. R. J. Tillyard, Chief, Biological Department, Cawthron Institute of Scientific Research :—3 species of Aphididae ; from New Zealand.

Mr. F. W. Urich, Government Entomologist :—10 Coleoptera, 12 Pentatomidae, and 150 Acarina ; from Trinidad.

Mr. Robert Veitch :—13 Diptera, 61 Hymenoptera, 222 Coleoptera, 47 Lepidoptera, 85 Rhynchota, 12 Orthoptera, and 7 Odonata ; from Fiji.

Mr. H. S. Wallace :—Examples of corks destroyed by Lepidopterous larvae ; from Newcastle-on-Tyne.

Mr. O. H. Walters :—125 Coleoptera ; from the Simla Hills, India.

Prof. H. H. Whetzel, Department of Agriculture, Bermuda :—5 Coleoptera ; from Bermuda.

THE LONDON HOUSE

. . . FOR . . .

MICROSCOPES

OUR ENORMOUS STOCK

Enables us to supply Microscopes of all powers and makes.

SEND FOR OUR LIST.

The Prices run from 17s. 6d. to £30.

The following are a few selections:—

Students'; Advanced; Hartnach; Society of Arts Microscope. Swift Student Microscope. Baker; Beck Star; Beck Triangular Foot Microscope. Beck Folding Popular Microscope. Beck Folding Popular Binocular Microscope. Beck "London" Microscope. Winkel Microscope. Reichert Microscope. Leitz Microscope. "Voigtlander" Microscopes. Zeiss Microscopes on sale from time to time.

Microscopes by all makers obtained at shortest notice. Exchange and repairs of all kinds.

J. WILLIAMS BUTCHER,

2 & 3 Ludgate Circus Bdgs., Farringdon St., London, E.C.4

Business Manager: E. W. Morton-George, to whom all communications should be addressed.

WATKINS & DONCASTER,

Naturalists and Manufacturers of every kind of Apparatus and Cabinets for Collectors of Insects, Birds' Eggs, Plants, Minerals, &c.

Plain Ring Nets, Cane, 2s., 2s. 6d.
Folding Nets, 5s. 6d., 6s. 6d.
Pocket Boxes, 1s.; corked both sides, 1s. 6d., 1s. 9d., 2s. 6d.
Zinc Relaxing Boxes, 1s. 6d., 1s. 9d., 2s. 3d., 3s. 6d.
Japanned Collecting Box, with strap, 8s. 6d.
Entomological Pins, mixed, 1s. 3d., 2s., 3s. 3d. per oz.
Mite Destroyer, 1¼d. per oz., 1s. 6d. per lb.
Sugaring Tin, with brush, 2s., 2s. 6d.
Store Boxes, with camphor cells, 4s. to 11s. 6d.
Ditto, Book Pattern, 14s. 6d., 15s. 9d., 18s.
Setting Boards, flat or oval, 1in., 9d.; 1½in., 1s. 3d.; 1¾in., 1s. 4d.; 2in., 1s. 6d.; 2½in., 1s. 10d.; 3in., 2s.; 3½in., 2s. 2d.; 4in., 2s. 4d.; 4½in., 2s. 6d.; 5in., 2s. 8d.
Setting Houses, 17s. 6d., 20s. 6d., 25s.
Zinc Larva Boxes, 1s. 6d., 1s. 9d.
Breeding Cage, 6s., 10s. 6d.
Coleopterist's Collecting Bottle, 1s. 6d., 1s. 8d.
Botanical Cases, japanned, double tin, 2s. 3d., 3s. 6d., 4s. 6d., 5s. 6d., 7s.
Steel Forceps for removing Insects, 2s. 6d. per pair.
Cabinet Cork, 7 by 3½, 2s. 3d. per doz.
Pupa Diggers, 3s. 6d. Insect Lens, 1s. 6d., 2s. 6d., 3s. 6d. to 15s.
Egg Drills, 3d. and 1s.
Metal Blow-pipes, 8d. and 10d.
Taxidermist's Companion, *i.e.*, a pocket leather case containing tools for skinning, 15s.
Egg Collector's Outfit, containing Drills, Blow-pipes, and all requisites, 4s. 6d. post free,

A Large Stock of Insects and Birds' Eggs (Singles and in Clutches). New and second-hand Books on Natural History.

Birds and Mammals, &c., Preserved and Mounted by first-class workmen.

36, STRAND, LONDON, W.C.2.

Five doors East from Charing Cross Railway Station (S. E. & C. R.).

(4183)

BULLETIN OF THE HILL MUSEUM

A Magazine of Lepidopterology

Edited by J. J. JOICEY, F.L.S., F.Z.S., F.E.S., and G. TALBOT, F.E.S.

Vol. 1, No. 1, with 24 photographic plates of Lepidoptera and 8 photographs of other subjects

Just Published 30/- net.

JOHN BALE, SONS AND DANIELSSON, Limited,

83-91, Great Titchfield Street, Oxford Street, W.1.

DULAU & Co., Ltd.,

34-36, MARGARET STREET, CAVENDISH SQUARE, LONDON, W.1,

Have always on hand a very extensive stock of works on the Natural and Physical Sciences—both Secondhand and New.

CATALOGUES SENT FREE ON APPLICATION.

Libraries or small Collections of Books Purchased. Distance no object.

SCIENTIFIC BOOKS & SERIALS.

WHELDON & WESLEY, Ltd. have the largest stock in the country of Books in all departments of Science and Natural History, also Transactions and Journals of Learned Societies, etc., in sets, runs, and single volumes or numbers.

A LARGE SELECTION OF BOOKS ON ENTOMOLOGY. ANY WORK QUOTED FOR.

——— LIBRARIES OR SMALL PARCELS PURCHASED. ———

SPECIAL CATALOGUES: Entomological, Botanical, Horticultural, Agricultural, Zoological, Chemical, Geological, etc. - - - - 2d. each post free.

38, GREAT QUEEN ST., KINGSWAY, LONDON, W.C.2.

Telephone: GERRARD 1412.

NOW READY.

An Abstract of the

LEGISLATION IN FORCE

in the British Empire dealing with

PLANT PESTS AND DISEASES

up to the year 1920.

LONDON: THE IMPERIAL BUREAU OF ENTOMOLOGY, 41 QUEEN'S GATE, S.W.7

Price 2s. 6d. net Post Free.

The Editor will be pleased to receive for publication papers or notes dealing with any insects that are of economic importance. Such communications to be addressed to

THE DIRECTOR,
Imperial Bureau of Entomology,
British Museum (Natural History),
London, S.W.7.

Orders and subscription for the "Bulletin of Entomological Research," of which there are four parts in each volume, should be sent to—

THE ASSISTANT DIRECTOR,
Imperial Bureau of Entomology,
41, Queen's Gate, London, S.W.7,

or through any bookseller.

The annual subscription (in advance) to Vol. XIII is Fifteen Shillings, post free; separate parts Five Shillings each, post free.

BACK VOLUMES. These may be obtained at part price, viz:—Vol. i, 14/6; Vols. ii—vii, 16/- each. Vol. viii, 14/-; Vols. ix and x, 16/- each; Vols. xi and xii, 20/- each, post free.

CONTENTS.

ORIGINAL ARTICLES.

PAGE

DRY, F. W. Trypanosomiasis in the Absence of Tsetses, and a Human Disease possibly carried by *Simulium* in Kenya Colony 233

EDWARDS, F. W. A Revision of the Mosquitos of the Palaearctic Region (*illustrated*). 263

FERRIS, G. F. Some Coccidae from Eastern Asia (*illustrated*). 211

LLOYD, Dr. LL. Notes on a Colour Tropism of *Asterochiton* (*Aleurodes*) *vaporariorum*, Westwood (*illustrated*). .. 355

MACGREGOR, MALCOLM E. The Influence of Drought upon Mosquito Life in Surrey 205

MOKRZECKI, Prof. S. A. *Agrilus foveicollis*, Mars., as a Cause of the Decay of the Culture of Roses in Bulgaria (*illustrated*). 353

MORRIS, HUBERT M. The Larval and Pupal Stages of the Bibionidae. Part I (*illustrated*). 221

PATTON, Major W. S. Notes of the Myiasis-producing Diptera of Man and Animals (*illustrated*) 239

MISCELLANEOUS.

Collections Received 361